Traffic Quarterly

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Driving Faults

WE have a tripartite system to control drivers: an agency to examine and license, an agency to enforce rules of the road and the conduct of drivers, and third, an agency to adjudicate cases. In some states, the licensor may suspend or revoke more licenses. The functions of these agencies are closely allied. Their objective—safe driving—can be attained only by close support and co-operation.

If we judge driving by sketchy statistics or inept comparisons, we ignore numerous faults. A criterion should not be based on the *consequences* of poor driving rather than on the faults or competency of driving. It is *faulty driving* that leads to accidents; a driver with habitual faults will invariably prove a driving failure.

a. Crossing the white line, failing to stay in the correct lane.
b. Failing to stop at a Stop Sign, or dangerously moving ahead of an oncoming car.
c. Making a left turn through a column having the right of way.
d. Making a turn or stop without signals.
e. Cutting curves.
f. Overtaking without sufficient sight distance.
g. Following too closely, often with bright lights.
h. Driving too fast for conditions.
i. Speeding, exceeding sign limits.
j. Careless, promiscuous and dangerous parking.
k. Usurping right of way.
l. Racing.
m. Discourtesy.
n. Slow driving.
o. Weaving.
p. Driving while intoxicated.
q. Contemptuous attitude.
r. Poor lights.

Many items in this list are habitually ignored and seldom admonished. The lack of ability or attitude to avoid them is just cause for severe action. A driver guilty of these faults is a menace—prone to accidents. He does not merit the privilege to drive.

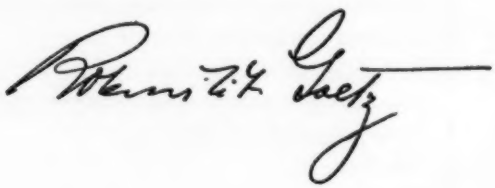
Many driving faults appear to be acceptable to the public, and, the police generally ignore them. This flagrant situation is disapproved but tolerated. The driving public is not fully informed—and part of it seems contemptuous of the requirements of a good-driving standard. Police are overwhelmed with the mass and variety of faults.

Existing authority should more definitely establish a higher good-driving standard. Most activity in the field of driver guidance has become a conglomeration of effort and confusion. Efficient driving is contingent on vehicle condition, road rules and conditions, driving ability, mentality, health, attitude and a reasonable degree of common sense.

The best drivers, with these essential qualities, are rarely predisposed to traffic violations. Many drivers fail to appreciate the implications in the issuance of a driver license.

Conditions under which a license is issued, with a list of prevailing violations, penal consequences, and conditions of forfeiture, should form part of the driver permit. The driver should be encouraged to appreciate his responsibilities, become conscious of his faults—and aware of the consequences.

We should persist with measures to raise our present driving standard. We should cultivate acceptable driving habits.



Land Use Analysis and Forecasting In Traffic Planning

ERNEST H. JURKAT

Mr. Jurkat is President of Marketers Research Service, Inc. in Philadelphia, Pa. He specializes in problems that originate in regional shifts and metropolitan concentration of the nation's growth and the accelerated decentralization and dispersion of population and business activity within metropolitan areas. He is a consultant on the Comprehensive Transit Survey and Study of the Metropolitan Area of St. Louis City and County; also to the City of Philadelphia, Urban Traffic and Transportation Board and City Planning Commission. Other recent studies in the field of public transportation planning he has been connected with include the Southern New Jersey Mass Transportation Survey and the New York Metropolitan Rapid Transit Survey. He taught sales forecasting at New York University and is a leciurer on marketing research at Drexel Institute of Technology.

I

RESEARCH projects for planning transportation facilities indicate that studies of the movement of persons and goods progress from the measurement of symptoms of facility requirements to a science that tries to establish the proper nature and dimensions of its subject by relating them to their causes.

This evolution has been slow, particularly in view of the progress in other fields of marketing research and the recognition of the interdependence of land use structure and movement through area probability sampling in origin and destination studies. If present universes of movement-volume and patterns can be projected by imputation from sampled residential or nonresidential establishments to like unsampled ones, it is also possible to derive future movement-volume and patterns from present establishments.

While the present simple and direct projection does not require any explicit identification of the land uses for which estimates are made, the projections for the future must be explicitly related to numbers and kinds of people, and to the kinds and capacities of es-

tablishments to and from which these people move and move their goods. Projections for the future necessitate the determination of traffic generation rates and measures for movement among land users.

So far, only two of the major movement studies have provided for information on land use (not to be confused with trip-purpose) at origin and destination: the survey conducted in connection with the Southern New Jersey Mass Transportation study and the O and D survey in progress in the St. Louis metropolitan area. Explicit determination of land use specific generation rates and patterns of movement are particularly necessary in areas for which no historical data on zone interchange are available; that is, in the majority of urban areas.

Generation Rate and Movement Pattern

A movement or traffic generation rate shows the number of trips from or to a specific zone per unit of land use in the zone. Land use may be measured in terms of number of people in residential or non-residential functions, square footage of floor space, acreage of land, value or volume of product handled and other types of quanta scientific ingenuity may conceive of. A movement pattern can best be described in terms of the frequency distribution of trips by length and direction.

A land use specific movement pattern is a frequency distribution of trips originating or terminating in a specific land use and also showing in each frequency class a distribution of land uses at destinations and origins respectively. A location specific movement pattern is a frequency distribution by length and direction of trips originating or terminating in a specific zone identified by its distance and direction from the center of gravity of the metropolitan area or region in which it is located.

The traffic-generating quality of a land use has also been characterized as an opportunity. In using generation rates for forecasting, the assumption is usually made that they are stable for the same measurement unit of the same land use. This is particularly the case as far as work trips are concerned. If a residential population includes 100 members of the employed labor force, or a plant em-

ploys 100 workers, either of them will generate close to 100 work trips a day during a normal work period of the year and week. This, however, is only approximately true. Differences in the effective distance between the locations of residence and work may result in greater absenteeism in the plants at the less favorable distances from residential areas than at the more favorable distances. The difficulty of measuring opportunity is more easily recognized for other types of trips. For instance, the proportion of shopping trips to floor space or sales clerks is not stable even within the same kind of retailing.

It is influenced by variety of merchandise, price range and service, and the income mix of the residents in the trade area determining the potential for variety of merchandise and price range. In view of this condition, shopping center development has been too exclusively the function of the architect and traffic expert and too little that of the marketing specialist. A great deal of research will be required to determine the refinements needed in traffic generation rates to develop them into the satisfactory tools for projection.

II

In trying to understand land use distribution for purposes of projection and planning, the author evolved a classification[1] found highly effective also in the analysis and projection of persons and goods movement. More than 270 standard industrial classes of nonresidential activities are consolidated into two major groups:

Functions primarily directed toward the handling of goods.

Functions primarily engaged in services requiring the direct handling of goods only accessorially and to a minor degree.

Four-Way Division

The goods-handling functions include manufacturing, wholesale trade with stocks, retail trade, warehousing and transportation services. The functions primarily directed toward the generation and handling of meanings and symbols include, among others, management and the services related to management, government, profes-

[1] Central District Study conducted for the Philadelphia City Planning Commission in 1949–50.

sional services, amusement and recreation, communication and wholesaling without stocks. While in the goods-handling establishment significant portions of the floor space and land occupied are taken up by goods, the floor space in non-goods-handling establishments is primarily used to accommodate people.

Each of the two major classes of land uses are further divided into two subclasses:

The functions typically addressing their products or services to the general public.

The functions typically selling to and serving specialized groups.

The first class includes, among others, manufacturing, wholesale trade and business services, and the second class, such activities as retail trade, medical services, financial services to consumers, amusement and recreational services, etc.

The four-way division of functions was designed to reflect the basic differences in land, building and floor space requirements and in linkages which are at the base of the differentiation of locational requirements and tendencies of the land uses. The effectiveness of this major classification for location analysis, projection and planning can be increased by further subdividing the establishments included in the four groups according to size and typical frequency and regularity of customer transactions.

Empirical Data

The subdivision of the urban functions as outlined above results in an organization of the empirical data needed as a basis for the synthetic conceptualization of the urban land use structure and its functioning. It makes it possible to measure and project the impact of modern socio-economic and technological developments on our metropolitan areas, and the tendencies and trends in spatial association and separation as well as concentration and decentralization/dispersion, and thereby provides the basis for constructing static and dynamic gravity models of nonresidential land uses.

The employment of "market linkages with the general public" as one of the principal criteria in the classification of nonresidential land uses implies that gravity models of the distribution of these

nonresidential establishments bear close reference to the density structure of the residential establishments.

Another strong factor in the interdependence of the two systems is that nonresidential establishments draw their population from residential establishments. The construction of a nonresidential gravity model, therefore, always necessitates the concurrent construction of, and integration with, a gravity model of residential distribution. Neither of them can be developed without reference to a common center of gravity for both and a unified concept and measure of locational equilibrium.

The principal elements in the static models of residential and nonresidential population are opportunity, density and distance, and factors that for any given point in the metropolitan field cause deviations from the relative proportions of the three principal elements normally producing locational equilibrium. However, there is one basic difference between the two systems which is of considerable consequence for generation rates and movement patterns.

The nonresidential model is mainly constituted by a distance-density distribution of function whereas the residential model is mainly constituted by a distance-density distribution of class. Since, for all practical purposes, class differentiation can be basically reduced to income differentiation, fewer problems of quantification are encountered in the construction of the residential than of the nonresidential portion of the gravity model.

III

Assuming that the classification of functions by spatial vectors is as significant and pertinent as this author believes it to be, models of metropolitan gravity are providing the basis for directly deriving geographical distributions of movement-generation rates in terms of origin as well as destination.

Since distance is one of the constitutive elements of structure and in this role reflects the spatial relationships among opportunities as modified by cost, it might also be hypothesized that the distributions in gravity models bear an equally direct relationship to the movement patterns; that is, the frequency distributions of trips from and to specific functions and locations by length and direction of trips.

It would follow that once a model for a metropolitan area has been developed movement patterns could be directly estimated for any given point, and traffic-flows directly derived among any points, in the urban structure.

Research to test this hypothesis is being pursued along two major lines:

Descriptively through multiple correlation analysis with trips from or to a functionally characterized zone as the dependent variable, and land use intensity at the destinations and origins respectively of these trips and distances among the zones involved, as the independent variables.

Inductively through comparative analysis in which the variations established in the multiple correlation analysis are related to position in the gravity fields of metropolitan models in as wide and varied an experience as possible.

Two Approaches

While the descriptive approach primarily aims at knowledge that applies to a particular area, the inductive approach aims at theorems formulated in the precise language of mathematics and of general validity at least within the boundaries of our socio-economic system. In either approach the principal subject of study has been the frequency distribution of trips by length, total and by direction, and particularly the effect of distance on trip lengths.

Movement patterns have been defined and measured particularly in two ways: as percentage distributions of trip lengths and as distance specific trip generation rates. A complete isolation of the effects of differences in land use intensity on patterns of trip lengths can only be achieved when they are standardized for land use intensity at the origin(s) as well as destination(s). The use of this "Intrinsic Pattern of Trip Lengths" has made it possible to establish that highly intensive land uses draw trips from greater distances than less intensive land uses of the same degree of uniformity, implying that distance is not an entirely independent variable but modified in its negative effectiveness by dimension of opportunity.

Resolving a Difficulty

The main difficulty in the inductive study of urban traffic as a function of land use is that the meaning and effectiveness of distance varies with the size of the urban area. An attempt has been made to resolve this difficulty by standardizing the direct measures of distance in terms of miles or time through relating them to ratios between land use intensities in the individual metropolitan areas. The distance-density model of gravity permits defining for each metropolitan area the ecological boundaries of the central city and for each particular sub-zone the density of its normal locational equilibrium.

Ratios can be computed between the normally expected densities of sub-zones and the density in their central city and equated with the distances of the sub-zones from their center of gravity. Identical ratios have been found to represent identically effective distances. This makes it possible to convert the mileage of any given metropolitan area into the mileage of same effectiveness of another and particularly of that selected as a standard. This device has been used in a study conducted by this author for the Metropolitan Plan Association, Inc. in New York in connection with the Metropolitan Rapid Transit Survey.[2]

In this study the attempt was made to relate work trip patterns to the land use structure in all urban areas for which empirical data were available and could be compiled and processed, and to discover whatever regularities in variation exist between the patterns of work trips and the position of their functionally defined destinations and origins in the field structure of metropolitan gravity. It was possible to generalize, in a preliminary way, the experience in urban areas of various sizes, age, and character into a common system of multiple co-variation of distance specific generation rates as well as intrinsic patterns of trip lengths with the distance of destinations and origins from the center of gravity and land use intensity.

The matrix can be used for purposes of estimation and projection in any particular metropolitan area if the standard measures of distance in the matrix are converted into the mileage and travel time of comparable effectiveness prevailing in the particular area. A

[2] A report on this study is being prepared for publication by the Regional Plan Association.

model was also developed for explaining the differentiation of distance specific trip generation rates by location of origin in relation to both destination and the center of gravity and the variation of this differentiation with distance of land use of destination from the center of gravity and its intensity. This model does not only explain the geographical dimensions of trip patterns but also the geographical dimensions of retail trade type sales potentials.

IV

In order to provide a basis for the derivation of future movement needs in terms of volume and patterns and the needs for transportation facilities which they generate, the gravity models of metropolitan land use have to be projectible; that is, they must be expanded into dynamic models. The potential for this expansion is contained in, and its direction indicated by, the concept of "locational equilibrium" which in the construction of the static model has been identified as the basic tendency governing the geographical differentiation of the residential and nonresidential functions.

Locational equilibrium can be defined as the relationship prevailing in a metropolitan area between the income potential (opportunity) for residential and nonresidential establishments and the location cost for these establishments. Income potentials increase as functions increase their productivity, overall dimensions and intensity of land use. Locational cost is constituted by two elements: (1) the cost generated by density; (2) the cost generated by distance to the sum total of opportunity and particularly its greatest concentration in the central business district.

Continuous Re-orientation

Distance cost is determined by physical distance in combination with travel speed and cost, which in turn are a function of the availability, capacity and efficiency of transportation facilities. If potential (opportunity) increases, locational equilibrium is sought at a higher level of density cost or distance cost or both. If density and/or distance cost decrease, locational equilibrium can be achieved with lower yields of opportunity.

In our modern society, locational equilibrium can be approximated only through a continuous re-orientation toward always new balances between the ever-changing potentials and cost, on the one hand, and between density cost and distance cost, on the other.

Since each particular equilibrium combination of potential and cost has its specific locus in the metropolitan field, the transition from one equilibrium combination to another will result in changes in the external dimensions of the metropolitan field itself as well as changes in the internal density patterns of both the residential and nonresidential functions.

Empirical models can be designed and computed—and have been designed and computed—to describe and measure the shifts in locations of density that go with changes in equilibrium combinations of values and vice versa. These models show a high degree of uniformity of structure and character of variation, reflecting the uniformity of forces determining external and internal metropolitan growth. The model for each metropolitan area, however, has also its own particularities. It differs from the model for any other metropolitan area in the dimensions and the constants in the functional relationships of its elements. These differences reflect differences in the size, age and economy of the metropolitan communities themselves.

In making it possible to define the adjustments in all other factors in the equilibrium balance which an initial change in any one factor will necessitate if locational equilibrium is to be maintained, and in making it also possible to define the changes in the geographical distribution of density that must occur if such initial change and subsequent adjustments are to materialize, the models open the way for predicting the geographical distribution of residential and nonresidential densities from the determinants of potential, distance cost and density cost. Most important among these determinants are the following:

(1) Increase of population and expansion of economic activity resulting either in higher density (and density cost) or geographical expansion (longer distances) of a metropolitan area.

(2) Increase of productivity leading to greater potentials and thereby providing the feasibility of higher density cost or higher distance cost; the feasibility of higher density cost leading to greater concentration of resi-

dential opportunity near all other opportunities or a quality improvement of residential opportunity, and the feasibility of higher distance cost leading to decentralization of residential opportunity.

(3) Improvement of public transportation facilities resulting in greater speed and/or service capacity; providing the feasibility of greater density cost and consequently leading to a decentralization of residential concentration to the areas served by the improved transportation facilities.

(4) Progress in transportation technology providing the possibility of private transportation (auto car), thereby making dispersion of residential and selected nonresidential opportunities feasible wherever the increase in distance cost is offset by a decrease in density cost.

(5) Decrease in travel time (distance cost) through speedways; increasing the dispersion potential by expanding the land supply and at the same time lowering the income requirements of dispersion; directing dispersion to the areas connecting with the high speed facilities.

(6) Institutional arrangements (for instance, FHA mortgage insurance) lowering the capital requirements for home ownership; thereby expanding low-density residential opportunity (dispersion).

(7) Increase in distance cost through cuts in the service capacity of public transportation, congestion on roads providing access to the areas of opportunity concentration and lack of parking facilities in these high density areas of nonresidential functions.

(8) Reduction of land supply at distances of possible locational equilibrium through slopes, swamps, lack of water and other natural conditions or zoning restrictions including pre-emption for industrial, recreational or institutional uses; with the effect of accelerating density and density cost at comparable distances, and increasing both density and distance cost, once the land supply at comparable distances has been exhausted.

(9) Retardation of growth by zoning restrictions and/or exceptional density cost which may be caused by the requirement of prohibitive investments for improvement or redevelopment or obstruction of use resulting from high density or incompatibility of functions. This retardation of growth will be compensated for by an acceleration of growth first at comparable effective distances and thereafter in areas and to a point where the sum total of density and distance cost remains below that in the retarded areas. After exhausting all possibilities of a more favorable locational equilibrium than can be realized in the retarded areas, the latter become competitive.

(10) Retardation of growth by exceptional distance cost which may be caused by natural barriers (very often large rivers) or the lack of travel facilities typically available in the metropolitan area at comparable physical distances from the center of gravity. The evolution in this case is similar to that under (8).

The principal aspect a dynamic gravity model has to define and explain is the geographical distribution of change in residential and nonresidential densities that will be compatible with uniform locational equilibrium ratios throughout the metropolitan area. This can be accomplished by relating the distributions of density change to the distributions of the factors that have been recognized as the generators of change (see previous 1 to 10). For purposes of simplification these factors can be basically accounted for by the following three elements of the urban structure:

Density at the beginning of the period of change providing a measure of the dimension of opportunity as well as that portion of density cost that represents the price to be paid for land and floor space.

Distance to the principal center of gravity (and major subcenters if such refinement is needed) representing a measure of the nearness to opportunity as well as of distance cost.

All other determinants of density cost including characteristics and quality of the land, cost of redevelopment and preemption of use.

The model also defines for each of the sub-zones in the metropolitan area for which it is constructed the particular combination of density, distance, conditions of land and, last but not least, density changes that are normally found and can normally be expected to produce locational equilibrium. In addition, it defines and explains the deviations from this normal combination that occur in specific areas, and particularly the deviations from normal density change that will result from deviations from the normal dimensions of distance or density or normal conditions of land, or from any combination of these deviations; also from a change of deviate dimensions and conditions respectively, of density, distance and land to normal ones. The dynamic model of metropolitan gravity represents a valuable tool not only for projection but also for planning. It permits determining and evaluating the effects which planning action related to density, distance and/or land will have on the geographical pattern of metropolitan growth and thereby anticipating the implications of and for this planning action.

It must be realized that the modes in which the determinants of locational potential and cost become effective are of a historical nature and that the degree of their impact changes in time. The estimation of future density distributions and planning therefore call

for projected dynamic models and for the computation of models for as many successive periods of equal length in the past as are required for such a projection. The historical models should always cover the whole range of the impact created by the motorization of private travel, that is, they should go back to 1910.

V

Since distance represents one of the constitutive elements in the urban structure—and the increases or decreases in distance one of the major causes of change in this structure—it becomes apparent that land use factors can no longer be looked upon as the independent determinants of movement and transportation facilities they have been considered. Recognition has to be given to the fact that traffic generators themselves are affected by the quantity and quality of transportation facilities.

Traffic planning is a two-way process. It has to develop hypotheses of possible requirements of facilities prior to the final projection of the generators that will determine the actual requirements.

It needs a trend projection of the dynamic gravity model for the formulation of the planning hypotheses (or possibly alternative sets of planning hypotheses) and thereupon needs a projection of the changes in land use that can be expected to result from an improvement of facilities in line with the planning hypotheses in order to determine the capacity requirements for the improved facilities.

Land use projections of this sort have been prepared for the Urban Traffic and Transportation Board, Philadelphia, and in the Southern New Jersey Mass Transportation Survey[3] and have provided the basis for the plans of the consulting engineers to the Delaware River Port Authority on the Southern New Jersey survey. Similar projections are now being prepared for a different set of planning hypotheses for the Urban Traffic and Transportation Board in Philadelphia.

The aspect of transportation that in a planning hypothesis is of primary interest to the forecaster of land use is the deviation of the effective distance of each sub-zone of a metropolitan area from its

[3] Marketers Research Service, Inc.: Survey and Forecast of Population and Employment for the Philadelphia–Southern New Jersey Transportation Region. August 1955.

center of gravity (and sub-centers of gravity if required) from the projected trend value of this effective distance that will be brought about by the improvement of facilities.

Effective distance was defined in the studies just mentioned as road distance in terms of time required to travel from the individual sub-zone to the center(s) of gravity and vice versa. It was indirectly and comparatively measured in terms of virtual miles; that is, the ratio of the product of normal physical distance for a given density as established by the model and actual time distance to the normal time equivalent of the model distance. The dynamic gravity model defines the co-variation between the deviations from model distances and the deviations from the normal percent changes of density. The effects of improvement in distance are computed by replacing in the estimating equation the trend deviations from model distance by the planned deviations.

In the absence of historical figures the future trend deviations of actual from normal distances can be derived from a projection of the secular change in the co-variation in the deviations from normal of physical distances and density, a method which was developed in a recent private study of this author on the Houston metropolitan area.

Accelerations in the improvement of travel time generally result in accelerations of decentralization and dispersion of the residential population and the goods-handling functions selling their products to special groups, and in greater concentration of all other nonresidential functions around the center of gravity and in sub-centers.

New Horizons in Urban Development via the Expressway

HUSTON RAWLS

Mr. Rawls is now head of a nationally known firm of consultants to chain stores, banks, department stores and industries, specializing in the location and development of sites of regional importance. His interests until 1945 were in the fields of investment banking, land assembly, and manufacturing. He was a pioneer in commercial and industrial development and transportation planning, of a regional nature. The largest project with which he is currently connected is the North Shore Center, a 1,000,000-square foot shopping center being constructed in Peabody, Massachusetts, by NORSCO Corporation, a wholly-owned subsidiary of Allied Department Stores Company. Mr. Rawls is the Director of NORSCO Corporation. The following article was prepared by Mr. Rawls in collaboration with David D. Longmaid, Neiland J. Douglas, Alexander B. Toland, and other officials of National Planning and Research, Inc.

THE problem of central city traffic congestion and intensive use of the downtown city's land is inseparable. For centuries people have moved to the central city area, first on foot and horseback, then on horse-drawn trolleys, later by subways and commuter rail lines.

Through these methods of daily journey to work, we have forced excessive crowding of people and jobs, and concentrated tremendous economic activity in a relatively small land area. Now, with the development of the automobile and its acceptance as an inexpensive universal means of conveyance, we face traffic impaction of the downtown area and the threatened breakdown of our regional transportation system.

The Philadelphia Urban Traffic and Transportation Board, after long and intensive study, succinctly states the problem in their recent report: "The Philadelphia region is becoming mired in a traffic problem so intense that the region's livability, its efficient functioning and its competitive power to attract population and industry are all seriously impaired."

Without question, metropolitan areas such as Boston and Philadelphia are on the threshold of a new and quickly changing era with the introduction of expressways. The tremendously expanded Federal Highway program is encouraging, but experts who have studied the magnitude of the problem agree that this is only a major advance and that additional financing will be required finally to resolve our present transportation dilemma.

The Philadelphia Urban Traffic and Transportation Board estimated the cost of a modern transportation system for the entire Philadelphia area at $1.6 billion in new capital outlays. To accomplish their recommended program in ten to fifteen years, it would mean more than doubling, perhaps tripling, present annual capital outlays of approximately $50 million, excluding funds available from the new Federal Highway program. Even with the Federal Highway program, it is evident that additional money will be necessary.

Ultimately these problems must be solved, and we should look ahead to the new horizons in urban development made possible by the realization of programs that will provide adequate metropolitan transportation systems.

Metropolitan expressways closely related to improved common carriers will be integrated with metropolitan transportation systems in our not too distant future. Such facilities will provide greatly increased accessibility to a larger number of opportunities, a broader distribution of jobs, recreation and places of residence. The effect of providing free, unhampered, swift and efficient movement of goods and persons also means a redistribution of land uses in our metropolitan areas.

A metropolitan area is so big and so complex it is sometimes easier to grasp the significance of expressways by reducing them to the simplest theoretical base, analyzing the component parts and then applying the findings to reality situations. The accompanying diagrams illustrate the impact of the expressway system on land use by showing the land area contributory to each expressway facility as completed. The diagrams are based on the following assumptions:

a. The diagrammatic metropolitan area is served by an infinite grid of north-south, east-west land access roads.

b. All vehicle speeds are assumed to be 18 mph on existing land

access roads. (Actually in driving 1500 miles of major roads in a large metropolitan area, average speeds in urban or built-up areas were clocked at 18.3 mph while at peak hours traffic moved slower than a walk in the central city area and the satellite centers.)

c. All diagrammatic expressways imposed on this pattern have infinite interchange points (no time allowed for interchange movement) with an average speed of 45 mph or 2.5 times average speed on existing land access roads.

d. Three destinations are used in each diagram: A) central city, B) on five-mile circumferential, and C) on ten-mile circumferential.

Diagram I. Radial Expressway

Many metropolitan areas have first constructed a radial expressway. This is true of Boston with the Charles River Expressway and Philadelphia with the Schuylkill Expressway. In theory, based on the above assumptions, the traffic shed or land area contributory to a radial expressway serving downtown destinations will cover a 180-degree arc. (See diagram IA.) Also shown in diagrams IA and IB are the "pull" or advantage ratios of a trip using the radial expressway.

For example, a person residing at any point on the expressway would have an advantage ratio of 2.5 to 1. (Expressway speed is two and a half times speed on land access roads.) As the would-be traveler moves away from the radial expressway, the advantage ratio quickly decreases. In diagram IA the advantage ratio finally reaches 1:1 or no advantage due north and due south of the downtown area. Note the changes as the destination moves north from downtown. The pull of a radial expressway is, therefore, very similar to a magnetic field.

In diagrams IB and IC the destination has been moved five miles north of center, then ten miles north of center. As the destination moves out from the downtown area, the land access roads compete with the radial expressway and reduce the latter's traffic shed. From diagrams IB and IC, it is evident that a radial expressway working by itself pulls traffic through the downtown area if the destination is north (or east) of the downtown business district. In other words, a radial expressway will tend to induce additional traffic into the congested downtown.

LEGEND:

Infinite grid of local roads

Land area contributory to radial

Land area contributory to circumferential

Destination

Direction of movement

Break-even lines

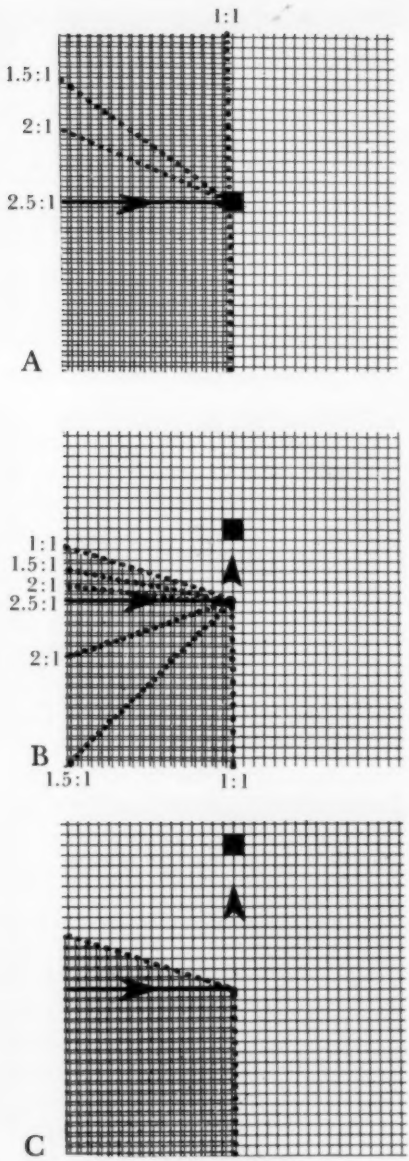
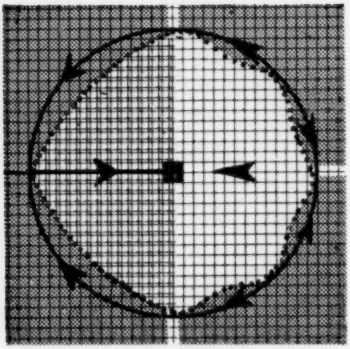
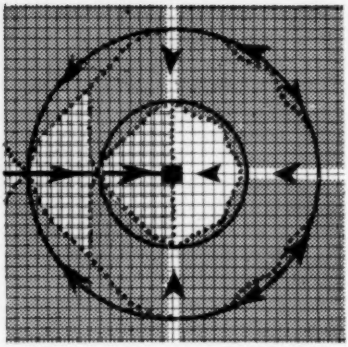
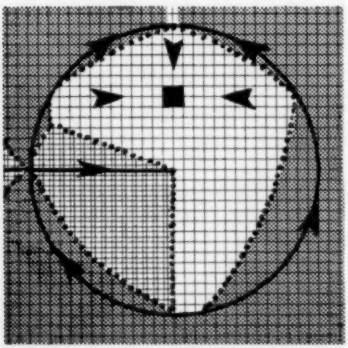
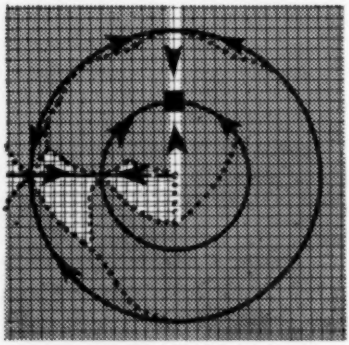


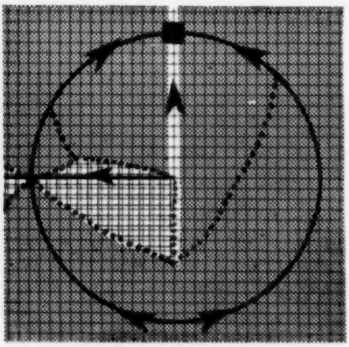
DIAGRAM I
Radial











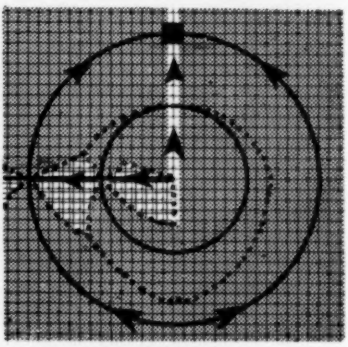


DIAGRAM II
Radial & 10 mile loop

DIAGRAM III
Radial & 10 & 5 mile loops

Diagram IA,B,C, showing the radial expressway working by itself in a metropolitan area, explains why underestimates of future traffic volumes for such a facility almost invariably occur. An added factor, discussed later in this article, is the rapid urban development in the suburban area, stimulated by the radial expressway.

Diagram II. Radial and Ten-Mile Circumferential

Boston is close to completion of its circumferential Route 128. Philadelphia is presently planning to construct a Delaware County Mid-County Freeway, tying into the extension of the Pennsylvania Turnpike from King of Prussia to the Delaware River, opened in the fall of 1955. From the diagram it is evident that the circumferential working with a radial accomplishes the following:

It increases the advantage ratio and by intercepting traffic outside its alignment increases traffic volume on the existing radial expressway. However, the circumferential does function as a distributor, as will be noted from the directional arrows in diagrams IIB and IIC. When the destination moves out of the downtown area, the circumferential tends to relieve the existing radial and, more important, reduces the need of passing through the downtown center.

Of greater significance is the reduction of traffic volumes on existing land access roads within the circumferential. There will undoubtedly be adverse or beneficial effects on land uses inside the circumferential. Certain types of business could suffer. Residential and institutional areas in this corridor belt will undoubtedly be protected from excessive traffic volumes when the expressway is built.

Diagram III. Radial, Ten- and Five-Mile Circumferential

The five-mile circumferential has been proposed in Philadelphia as an added distributor and also to handle close-in peripheral movement. The diagram indicating the land area contributory to each facility shows clearly the interaction between the facilities. Note how one part of the system competes with another; also the minor reversals of expressway traffic-flows away from the center. A total pattern of expressways or a system with additional radials, etc. could be analyzed in this manner.

Several conclusions are evident from these diagrammatic studies.

a. The extent or area of the traffic shed contributory to an expressway (i.e. the radials, outer and inner circumferentials) is subject to extensive change as other sections are added. Therefore, any component part must be considered as a functional part of a total expressway system.

b. On completion of an expressway system, islands of land surrounded and serviced by the expressways will be the dominant pattern. Traffic within these islands should be principally local and, instead of flowing on existing land access roads toward the central city, will tend to move toward convenient interchange points with the expressways.

c. Extensive reorientation of traffic-flows will gradually occur when the shortest distance between two points is no longer the straight line but the quickest measured in minutes and convenience.

d. Through the diagrams, relationship of the circumferential and the radial is clearly evident and its application to a total system for a metropolitan area could conceivably determine priorities and scheduling for a construction program.

e. The diagrams reinforce the oft-stated hypothesis that city, county and municipal boundaries are meaningless when approaching a solution to metropolitan expressways. The plan must be developed within the context of the region as a whole.

Studies Afford Programming Advantages

The studies have perhaps oversimplified certain aspects of our present metropolitan complexities, such as varying densities of population or trip generators, especially the extreme high-density development in and near the central city business district. They have also failed to recognize the sub-centers in our metropolitan areas where commercial or high employment concentrations exist.

The diagrams also overlooked the role of common carriers that must increasingly reinforce the radial movements serving the central city. The Philadelphia Urban Traffic and Transportation Board stated in their recent report, "At the present time, fifty out of every hundred trips to the central business district on weekdays are made

Chart I

Chart II

Chart I shows the area within 30 minutes drive of downtown Philadelphia on existing highways; Chart II, the area within 30 minutes drive of downtown Philadelphia on completion of a regional expressway system.

by public carrier. This ratio rises to seventy out of one hundred during peak hours." It would obviously be disastrous if present patrons of the public carriers decided to shift to cars.

Unless railroads succeed in abandoning commuter traffic, public carriers must compete with expressways in speed (total elapsed time from home to job), convenience and pleasantness. In addition, they must tie to the expressway systems and encourage shifts from car to public carrier for trips especially to the downtown area. Circumferential expressways, cutting across existing rail lines, are especially well-suited to this solution. In this way public carriers will complement expressways and not be displaced by them.

Also inherent in the diagrams, but not spelled out, is the expansion of land area accessible to the downtown center. A study indicates that the land area within thirty minutes of Philadelphia's city hall by automobile will be approximately tripled by construction of a complete system of expressways. In effect, the introduction of this tremendous land area into the metropolitan land market might tend to depress present land values.

However, the demand is so great that a tremendous increase in land values is occurring in the suburban areas tapped by new expressways. At King of Prussia, eighteen miles west of central Philadelphia, experience proves this point. Just after the war, farm values were $400 to $500 an acre. In 1950 with the completion of the Pennsylvania Turnpike from Harrisburg to King of Prussia and the announcement that the state would build the Schuylkill Expressway (freeway) from King of Prussia to central city, land values climbed to $1,200 and $1,500 an acre for residential subdivision land. Last year the asking price for a 120-acre golf course near the interchange was reported as one million dollars or about $8,000 an acre.

Already apparent is the vast increase of our appetite to utilize the new land supply. In Southeastern Pennsylvania the regional planning commission, reporting on subdivisions approved by the Bucks, Chester, Delaware and Montgomery County planning commissions, stated that 18.4 square miles of land in the four-county area were approved in 1955 for subdivision development; 15.8 square miles in 1954; and 12 square miles in 1953. This makes a total of 46.2 square miles or about one-third the size of Philadel-

phia's area slated for new residential development in the three-year period. Plans were approved for a total of 73,471 building lots or roughly 2.5 houses to an acre. Compare this to the 1920 to 1930 building boom which consisted largely of row houses within Philadelphia at eighteen or twenty to the acre, and one can visualize the present appalling demand for land.

The Southeastern Pennsylvania regional planning commission estimated that the total urban land requirements for all types of land uses—residential, industrial, commercial, parks, institutions, etc.—would more than double in the Pennsylvania portion of the Philadelphia Standard Metropolitan Area by 1980.

Development Patterns Interrelated

One must consider the evolving patterns of our metropolitan expressway systems against this backdrop of constantly increasing appetite for land for urban use. In the suburban areas expressways will create focal points for intense urban development. This development could take the form of an integrated regional shopping center, an office building complex, high-story apartments, a campus-type industrial park, or combinations of these uses.

It is practical to visualize the development of important suburban transportation centers occurring where circumferential expressways permit interchange to public carriers. These subcenters could support office-building complexes and provide public transportation for the secretary or individual who is not able or does not prefer to drive a car to work.

Intensive urban land use represented by this type of development cannot be scattered hither and yon in the region. The cost of providing necessary services—sanitation systems, water, transportation, etc.—becomes excessive. Clustered new development related to focal points of the expressway system seems the logical pattern that should be followed or conversely, expressways should be designed and engineered to encourage this type of growth.

As the expressway system takes form and substance, some of the existing development will be strengthened and reenforced. The mayor of New Rochelle, commenting on the soon-to-be-completed section of the New England Thruway—designed to make the city's

streets again available for shoppers in by-passing trucks and heavy through-traffic—stated, "This is the greatest single event in the city's history." Boston's proposed extension of the Massachusetts Turnpike into the downtown area should have a similar beneficial effect on presently congested shopping areas in that sector of the city.

New locations for urban growth are being created, some existing areas are being strengthened; but certain areas undoubtedly will be weakened or adversely affected by the final pattern of movement resulting from construction of the expressway system. Business today is faced with many complex problems brought about by this rapidly changing urban pattern. Questions that arise can no longer be answered over a cracker-barrel; solutions must be based in many instances on highly technical data and on an overall knowledge of existing trends. Sound and knowledgeable decisions by private enterprise coupled with well thought-out plans and public policies by government can use expressways as a tool to achieve free, swift and safe mobility in our metropolitan areas.

A first step in an orderly approach toward new horizons in our metropolitan areas is the development of metropolitan-wide regional plans for expressway systems that are pinned down as to exact alignment, right-of-way width, and location of interchanges. This has been advocated before so that rights-of-way can be acquired in advance; however, it is suggested here to provide a much needed frame of reference in which private initiative and private capital can make their plans and decisions. Only when responsible public bodies have made these plans can private enterprise move forward co-operatively with them.

County Traffic Engineering

W. C. BRANDES

Mr. Brandes was appointed County Traffic Engineer for Dallas County, Texas, in January, 1952. Previously, he was for five years Director of the Department of Traffic Control for the City of Dallas. During two of those years, 1945 and 1948, the City was awarded national first place in traffic engineering achievements in its population class. From 1931 to 1943, Mr. Brandes was Traffic Signal Engineer for the City of Chicago. He is a member and past-director of the Institute of Traffic Engineers and chairman of the specifications committee which produced the first American standard specification for fixed-time traffic signal controllers.

TRAFFIC engineering within county units of government is sufficiently rare in this country to warrant some special attention. From information available, the entire United States has not many more county traffic engineers than one could count on his fingers. Essex County, New Jersey and Wayne County, Michigan were probably the first in the field.

With the current trend of suburban living and the spread of traffic congestion outside the cities and into the country, there is obvious need in more counties for the trained traffic engineer. Naturally the highly urbanized counties in metropolitan areas will require these services first; but if population growth in urban centers continues, many cities will have spilled their inhabitants into surrounding unincorporated areas.

Those former city residents have a peculiar liking for traffic regulations to which they have been accustomed. The mere fact they have left city boundaries does not mean they will not request speed zones, stop signs, signals and other safety measures throughout the area in which they live. County administrators then will realize they are not equipped to handle such requests. County residents are generally in closer contact with their elected representatives than are city dwellers with their councilmen.

It is believed therefore that the next decade will see a large number of county governments turn to part- or full-time use of traffic engineering.

The basic criteria of need for a county traffic engineer involve several factors or conditions. These might be listed as:

a. Population, density, and distribution.
b. Motor vehicle registration.
c. Community development and travel.
d. City fringe needs.
e. Accident experience.
f. Aid to suburbs in traffic problems.

A. Population and Its Characteristics.

Naturally, population is important to the traffic engineer. Without concentrations of it, he is not needed. Population in metropolitan counties is obviously of three classes: central city, suburban towns, and rural. The density will vary tremendously between the city and rural classifications. An extremely large county will have a low *average* density, heavy concentrations over small areas.

Populations

In Dallas County, Texas, the population in 1950 was 614,800; with the county's area of 893 square miles, the average density was 688 persons per square mile. That is not high as densities go but it is 50 percent higher than the second densest county in the state, Harris, in which Houston is the central city. Average population density within Dallas corporate limits in 1950 was 3700 per square mile; in other municipal areas of the county it was 2877 and in the non-incorporated areas 136 per square mile.

Naturally, the outer fringes of the county are for the most part still sparsely settled. This means that in the fringes of and outside the city, population is relatively dense.

B. Motor Vehicle Registration.

The number of vehicles in a county also is of prime importance. Vehicles are the life blood of the traffic engineer's profession. The rate of their increase is reflected directly in the use to which existing facilities must be put. New roads and streets are forever falling short of increased ownership and use of vehicles.

Citing again Dallas County, vehicle registration has virtually sky-rocketed. All vehicles numbered 245,228 in 1950, a gain of 83 percent over 1940; in 1955 it was 366,081, an increase of 49.3 percent in five years. The projected registration for 1960 is 470,000 vehicles. Persons per vehicle registered were 2.51 in 1950; in 1955, they were approximately 2.1. Stated differently, we have almost one and a half passenger vehicles per family. Figure 1 shows registration from 1930 to 1955.

C. Community Development and Travel.

Substantial growth of suburban towns whose population is primarily reliant upon employment in the central city, results in continually increasing travel-miles daily. Some portion of that traffic will obviously occur on county routes, while the balance will be on state highways.

In many cases too, a large industry in one suburb will draw employees from neighboring towns where there are no inter-connecting state routes to serve them. An outstanding example of this condition is found in Dallas County. Similarly a major shopping center in one suburb may draw customers from nearby towns via county roads.

D. City Fringe Needs.

The vast amount of daily travel between suburbs and central city results in a heavy burden in the county area just outside the city's perimeter. Intersections, too, on such heavily traveled routes, require proper traffic regulation and control by the county. Some intersections just outside the city may carry heavier vehicle volumes than similar intersections in the city where traffic signals are in operation.

Hence the county obviously must furnish the same form of control. In some instances pedestrian protection requires as much attention as in the city—near large industrial plants or schools. It is primarily in these areas that a county traffic engineer will devote much of his energy.

E. Accident Experience.

This is another factor that may determine the need of traffic engineering services. It is believed that most counties do not maintain

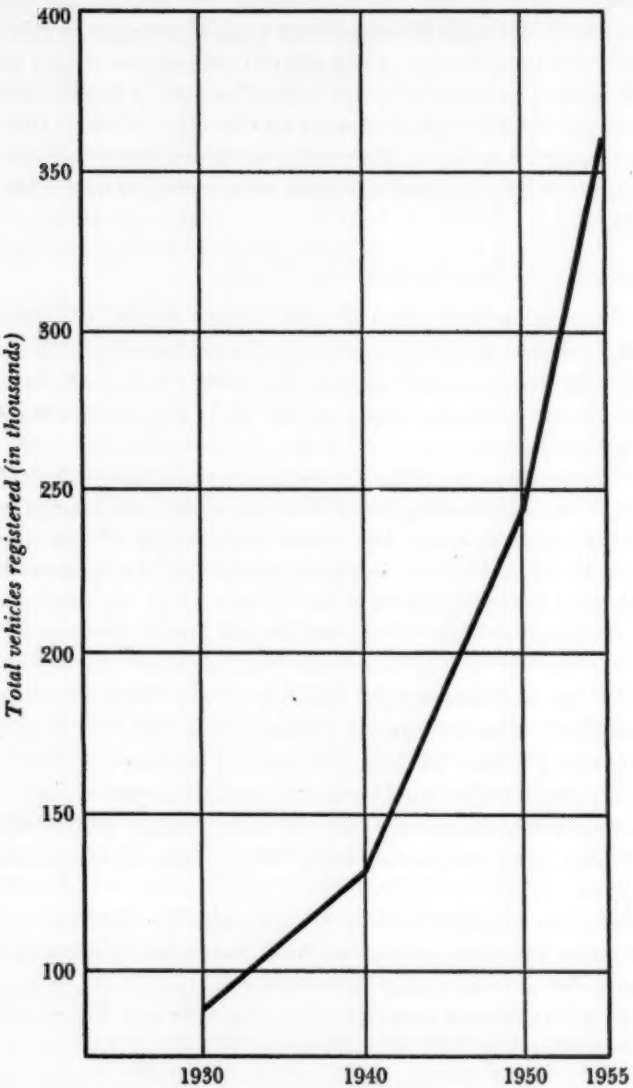


FIGURE 1. Vehicle registration, Dallas County, Texas.

traffic-accident records in a form usable to ascertain the more hazardous or high-frequency locations. This the traffic engineer can readily do when such records are made available to him.

Where regular publicity is given to county versus city accident or fatality records, there can be embarrassment to county officials unless some attempt is made to rectify an unfavorable position. The job cannot be left to the enforcement agency when engineering measures are required. Generally speaking, the county engineer is not a traffic specialist and thus may not be able to solve a specific traffic problem.

F. Community Traffic Problems.

The smaller suburbs about a city—those without their own police department or city engineer—are strongly inclined to look to the county for aid in regulating traffic. Even the larger towns will seek consultation and advice if the county has available a traffic specialist. The goal that can be achieved by such county participation is definitely in the public interest. Uniformity of control devices and a lowered accident record county-wide are accomplishments in which top county officials can take pride.

These factors can be used only as a guide in determining the need for county traffic engineering services. It is acknowledged universally that state highway departments require and use staffs of traffic specialists who supervise methods and techniques of properly handling traffic over the state-wide system. It is also acknowledged that after years of experience in city traffic engineering administration, a minimum population figure has generally been accepted to justify employment of a full-time traffic engineer—50,000 people.

In the case of counties, our national experience has been so limited that it may seem premature at this time to attempt to set forth any specific basis, paralleling that of city or state, for establishing a county traffic engineering position.

Until further experience is gained, however, a premise is suggested: that those counties having a population of more than 500,000 might definitely have need of a traffic engineer. By the 1950 census, the entire United States had a total of thirty-eight counties in that population category. By eliminating four of these counties in which New York City is located, and four others where the central city and

county areas practically coincide, there remain thirty counties. In those the county-wide population density ranges from 131 to 7,080 persons per square mile. Statistics are not at hand to determine the population and density in (1) suburban incorporated and (2) rural areas, which obviously would be a determining factor to be considered.

Counties over the country vary extensively in traffic characteristics, even in metropolitan centers. Hence such other factors as vehicle registration, number of miles of county roads, etc. must be taken into consideration.

The County Traffic Engineer's Function

The county traffic engineer actually is a cross between a city and state traffic engineer. His field lies between the two.

While states as a general rule exercise some control over cities and towns with respect to uniformity of traffic control devices and their intended use, county governments, at least in Texas, do not attempt any form of dictation in county towns, even though certain of their pavements may be county-maintained.

A State Manual is precedent over the entire state and while municipalities are furnished copies, the county can only advise its proper use. The county as well as the state can and should set good examples in traffic engineering methods for the smaller towns to follow. On the other hand, officials of larger towns will often adopt traffic control practices peculiar to the central city without advice from the state or county.

The central city will expect aid from the county in properly controlling congestion just outside the city boundaries which affects flow into or out of the city. The county traffic engineer is expected to work closely with his counterpart in the city toward solving traffic problems inside and outside the city fringes. His work therefore covers both rural and urban conditions. In addition, he is frequently called upon for aid in county towns of varying size; here his role is actually that of a consultant.

The county traffic engineer has to deal with county roads on which vehicle speeds must be posted for 30 mph or even less in congested areas; possibly as high as 60 miles per hour in rural areas

where the state speed law applies. His sign sizes thus must fit city and rural standards. Over-size signs are frequently required.

Legal Authority

Until recent years, no county in Texas had any legal authority to control or regulate traffic on county roads in the non-incorporated areas. The need was great in some densely populated but non-incorporated areas in Dallas County and the same situation probably existed in some other counties. It was particularly vital to the Dallas County sheriff concerned with an accident problem without adequate authority to cope with it.

Through concerted local effort, a special bill (H.B. No. 207) was introduced in the 52nd Texas Legislature in 1951 which would give to Dallas County specific authority to regulate its traffic. Such authority was vested in Commissioners' Court and applied only to those roads under its jurisdiction. That embraced all county roads in non-incorporated areas and of course exempted all highways in the state highway system.

Enforcement of traffic regulations on the state system still devolves upon the county sheriff, aided by the state highway patrol, but the promulgation of traffic regulation on such highways rests with the state highway department. Thus the county cannot institute such measures as speed zones, or even install a traffic sign on any state or federal-aid highway.

For informational purposes the first bill is given here verbatim. It was revised by the next Legislature to include more counties in the state. In the first law, the county population figure of 500,000 covered only three counties, Dallas, Harris, and Bexar which includes San Antonio. In the population figure subsequently revised to 150,000, nine counties are included by the 1950 census.

COUNTY ROADS—TRAFFIC ZONES

CHAPTER 302

H. B. NO. 207, 52ND LEGISLATURE

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF TEXAS:

SECTION 1. The Commissioners' Court of any county in this State having a population of five hundred thousand (500,000) or more according to the last

preceding Federal Census is hereby authorized to create and establish restricted traffic zones on county roads under their jurisdiction.

SECTION 2. The limits of said traffic zones shall be set forth in the minutes of the Court, and said Court shall have the power and authority upon the basis of an engineering and traffic investigation to determine and fix the maximum, reasonable and prudent speed at any road or highway intersection, railroad grade crossing, curve or hill, or upon any other part of a county road less than the maximum fixed by law for public highways, taking into consideration the width and condition of the surface of the road and other circumstances on such portion of said road as well as the usual traffic thereon. Whenever the Commissioners' Court of any county shall determine and fix the rate of speed at any such point upon any county road at a less rate of speed than the maximum fixed by law for public highways and shall declare the maximum, reasonable and prudent speed limit thereat by proper order of the Court entered on its minutes, such rate of speed shall become effective and operative at said point on said highways when appropriate signs giving notice thereof are erected at such intersection or portion of the road under order of the Court.

SECTION 3. The Commissioners' Court of any county having a population of more than five hundred thousand (500,000) according to the last preceding Federal Census may adopt rules and regulations consistent with this Act for the establishment of a system of traffic control devices within restricted traffic zones established on county roads under its jurisdiction and such system shall conform to the State Highway Department's manual and specifications. The Court may, pursuant to order entered on its minutes, place, erect, install and maintain upon county roads within traffic zones such traffic control devices, including but not limited to traffic signal lights and stop signs, as it may deem necessary for the public safety.

SECTION 4. The Commissioners' Court of any county having a population of more than five hundred thousand (500,000) according to the last preceding Federal Census, with respect to roads under its jurisdiction, may place signs prohibiting or restricting the stopping, standing, or parking of vehicles on any road within a restricted traffic zone where in the opinion of the Commissioners' Court such stopping, standing, or parking is dangerous to those using the road or where the stopping, standing, or parking of vehicles would unduly interfere with the free movment of traffic. Such signs shall be erected pursuant to order of the Court and it shall be unlawful for any person to stop, stand, or park any vehicle in violation of the restrictions stated on such signs.

SECTION 5. Any person who shall deface, injure, knock down or remove any sign or traffic control device erected pursuant to an order of the Commissioners' Court as provided in this Act shall be guilty of a misdemeanor.

SECTION 6. Any person operating a motor vehicle in violation of any order of the Commissioners' Court entered pursuant to this Act or otherwise violating any provision hereof shall be guilty of a misdemeanor and shall upon conviction be punished by fine not exceeding Fifty Dollars ($50) for the first of-

fense; by a fine not exceeding Two Hundred Dollars ($200) for the second offense; and by a fine not exceeding Five Hundred Dollars ($500) or imprisonment in the county jail not to exceed sixty (60) days, or both such fine and imprisonment for each subsequent offense.

SECTION 7. If any portion of this Act is held unconstitutional by a Court of competent jurisdiction the remaining provisions shall nevertheless be valid the same as if the unconstitutional portion had not been part of this Act.

SECTION 8. The urgent need for effective regulations of motor vehicle traffic on roads under the jurisdiction of the Commissioners' Courts creates an emergency and an imperative public necessity that the Constitutional Rule requiring bills to be read on three several days in each House be suspended, and said Rule is hereby suspended, and that this Act shall take effect and be in force from and after its passage, and it is so enacted.

Effective Date: May 23, 1951.

Location of County Traffic Agency

This law does not prescribe the position of traffic engineer and does not delegate authority to any traffic agency, if one were set up. Control of all county traffic is vested only in Commissioners' Court and discretion as to how or through whom traffic control responsibilities may be handled is left entirely with the Court.

No doubt the form of Texas county government will interest readers in other states in which it may be different. Here we have four county commissioners, each representing a specified district (actually called precincts) throughout the county. Each Commissioner is elected by the voters in his precinct only. The county judge, though he need not be a member of the bar, constitutes the fifth member of the County Commissioners' Court.

The judge is elected by eligible voters in the entire county. In Commissioners' Court meetings the judge has a vote only in case of a tie between commissioners. Terms of office for all five officials has been two years but this very recently was changed to four years, with two new commissioners being elected every two years.

Subsequent to establishment of legal authority in Dallas County consideration was given to hiring a consulting traffic engineer on a retainer basis. However, on recommendation of officials of the Citizens' Traffic Commission—an independent and purely advisory body —and the county engineer, a full-time traffic engineer was appointed early in 1952. The traffic engineer was placed in the county engi-

neer's department and his budget funds are part of the county engineer's budget.

Whether this is the ideal arrangement is possibly debatable but in this instance it has worked out very well. Drafting aid, road maps and drawings are immediately available to the traffic engineer, as well as additional personnel aid when necessary. Support from Commissioners' Court also has been most gratifying.

As allowed in H.B.207 and subsequent revision, since no delegation of power was provided, every traffic control device must be approved formally by Commissioners' Court and entered on its minutes. Every traffic sign, even of the warning type, is processed by a court order before being erected. In a regulatory type, the court order must establish that portion of the road wherein it is to be placed as a "restricted traffic zone." This entire procedure, however, is not complicated or delaying since Commissioners' Court meets regularly semi-weekly.

Functions and Responsibilities

These actually do not differ materially from those within a city or state organization but are rather a mixture of the two. It may be of interest to describe what a traffic engineer does in a county more or less typical in the metropolitan category. Dallas County maintains 1264 miles of roads of which 995 miles are paved.

With the beginning of a traffic engineering program in Dallas County, it was primarily important to make a survey of all major road sections and intersections for traffic-sign needs. That survey would include an inventory of type and condition of any existing signs. Later the justification of existing regulatory signs was investigated.

Priority given to sign installation was based on two premises; first, to catch the more hazardous locations for warning signs, and second, to treat the most heavily traveled intersections for regulatory measures. By studying the last year's fatality and major accident record and a pin map in the sheriff's office, the high frequency locations could be quickly spotted. Following that, all major roads were carefully driven, the more heavily traveled first, and usually in both directions. Extensive field notes were made of all physical conditions.

By this method the most urgent need for warning signs was determined—at narrow bridges, restricted sight distance on approach to a 90-degree turn, a sharp curve or "T" intersection, etc. From the quick survey of hundreds of miles of major roads, a substantial number of warning signs were put into service in a relatively short time. This gave county residents not only immediate benefits but also left with them the impression that traffic engineering in the county was functioning quickly. Regulatory signs, such as stop and speed zones, obviously required more study.

In the first few months, too, all existing stop-sign locations were reviewed for justification of the regulation. Some were removed by permission of the court while all others were made legal in the required procedure. It developed that all such stop signs had been installed without legal authority and thus could have been contested in criminal or civil court.

Most of the stop signs were of the plain type difficult to see at night, and had to be replaced with light-reflecting type. The legislation cited above requires that all traffic control devices installed on county roads must conform with the state highway manual pertaining thereto. A few signs had been in service for a long time and did not conform in shape with national or state standards.

The rapidity in placing the first warning signs on the roads was increased by an agreement between the county and city of Dallas whereby the city would furnish to the county all standard, reflective signs on a cost-plus basis. Thus time was not required for determining long-term needs, drawing of specifications, advertising and awarding of bids. That practice, however, has since been discontinued and signs are now purchased through competitive bidding by commercial sign companies.

County Program Since 1952

In January, 1952, the county operated and maintained traffic signals at six intersections. Just prior to that time the state highway department had taken over the operation of signals at four additional intersections, placed by the county on state highways by agreement. This was before the state began any signal installations. Subsequently the county installed signals at three additional intersections, just outside

the city fringe, with one of them requiring a 3-dial-type controller.

The institution of speed zones on county roads has followed normally wherever justified. That, however, has not involved many miles of roads. The older and narrower county roads simply do not lend themselves to dangerously high speeds. Naturally, a small percent of drivers ignore the confining aspects of such roads but speed limit signs would have little or no effect on them anyway. Long sections of straight alignment are the exception rather than the rule on county roads. Conditions of pavement surfaces generally have a more inhibiting effect on speed than signs.

About two years ago, the county embarked on a program of pavement marking. This includes center-lining and marking of no-passing zones on such center-lined roads with reflectorizing paint. The more common standard of broken center-line in white is used, with "no-passing" a solid yellow line next to the center-line. This standard was adopted by the State of Texas after Dallas County began using it. Prior to that, the state used the asphalt and aggregate line entirely.

At present, Dallas County is marking approximately 175 miles of county roads annually, about the limit that present personnel and equipment facilities can handle. It represents only those roads which carry more than 500 vehicles per day. However, markings are carried to some extent within the corporate limits of smaller towns, for which their officials are grateful.

In 1953, the county purchased two recording-type traffic counters. These are in service most of the time and provide current volume data. In addition, the state highway planning survey periodically makes counts throughout the county. Every two to three years a map is furnished showing vehicles per day on every road outside municipalities. Release date of the map, however, necessarily lags considerably behind the period of count.

All accidents in the county investigated and reported by the sheriff's office are recorded in brief form by the traffic engineer's staff. These include all state highways. File cards are maintained by road section and an accident spot map is kept up to date. All accidents occurring in smaller county towns are investigated by the sheriff; in larger towns the local police department investigates and does not report to the sheriff. All fatal accident records, however, are available.

Special Studies and Services

Other operating functions involve the county traffic engineer. For example, in Dallas County during 1956, the recommendation of the traffic engineer for a much needed road-marking project was approved and supervision of the entire project turned over to him. This included listing all intersections, the type of marker or sign, selection and testing of materials, specifications and purchase. Following delivery, the traffic engineer's crew divided up and each man supervised installation of the markers by road-district forces. Initially an order for more than 2500 sign plates was placed and with some signs on hand, approximately 700 intersections were marked. This number represents only main county-road intersections and about fifty additional intersections are awaiting official changes in road names. The next stage of the project will cover sub-division streets.

Special events require study and co-ordination with the sheriff's deputies in the handling of crowds, special signs, etc.

In 1952, soon after the traffic engineering position was established, a national golf tournament was held at a country club in a rural county area. An overall plan of traffic circulation and control was provided by the traffic engineer. Parking on several county roads was prohibited over a five-day period by court order. Numerous control signs and pedestrian cross-walks were installed as well as directive signs to the several parking areas. Without the legal authority for traffic control only recently enacted prior thereto, there might have been chaotic conditions occasioned by the huge daily attendance at this tournament.

Special studies also are now and then assigned to the traffic engineer. An example was a study and report on a parking facility for official county automobiles in the vicinity of the court house and county offices. While the time for providing such a facility apparently is not yet at hand, it will develop without a doubt.

A major and time-consuming function of the county traffic engineer may develop in the form of consulting service to county towns. Town officials look to the county for aid in many of their problems, more than to the state. The largest towns of Dallas county have

requested overall traffic surveys with recommendations for new planning and traffic control measures. Or they may request a study and review of their existing traffic techniques. In rapidly growing towns requests have come for succeeding surveys to bring previous reports up to date.

While these services can only be rendered when available time permits, town officials seem willing to wait their turn in securing this free service in preference to hiring an outside consultant.

County-wide Traffic Planning

Future planning of a county-wide thoroughfare system is vitally important in an area that is rapidly expanding in population and economy. Even though a grid system of properly spaced major roads exists, there will be need for widening, straightening, and additional secondary arteries. Planning and improvements must follow the pattern of population distribution. The county net-work must fit in with the central city's major street system as well as with those in various county towns.

Thus the closest kind of co-ordination between municipal and county officials is required. If the commonly found political obstacles can be overcome, it is best to have a county-wide or metropolitan area planning council. Such a group should be more than advisory; it should have sufficient authority to attain the objective desired: a master thoroughfare plan specifying proper right-of-way and pavement widths which over the years can be put into effect.

Securing of necessary rights-of-way should be a continuing process well ahead of immediate construction needs. Though taxpayers may not be aware of it, postponement of right-of-way acquisition in fast-growing communities is a costly waste of public funds. Good planning and wise fiscal policies will pay off in substantial mileage of additional roads that can be bought for the same capital outlay.

In Dallas County a joint city-county bond issue of $22,500,000 was floated in 1950 for road improvement. New roads were built within and without the city of Dallas, others were widened and improved and numerous worn-out bridges were replaced with new ones of ample width, several of four-lane capacity. Certain sums also were earmarked for right-of-way acquisition.

Since completion of the construction program and depletion of these funds, no new funds for right-of-way purchase are available. In Texas all rights-of-way for the state and federal-aid system have been provided from the beginning by counties and cities. Actually only the few largest cities have participated. Dallas County with a substantial mileage of state and federal highways has been unable to keep up with state construction funds.

Dallas County, by legislation enacted in 1953, has the authority to establish "set-back lines" for future improvement on all state and federal highways and also on county roads in non-incorporated areas. This authority, however, is contingent upon proper and prior planning and adoption of a specific plan in the areas affected. To date the only action taken under this legislation applies specifically to state and federal highways planned by those agencies. Lack of funds to purchase right-of-way in cases of desired improvements by land owners has held off any establishment of set-back lines on county roads.

In 1950–51, a city-county traffic survey was conducted with the aid of the state highway planning survey. Although this study was focused mainly on the city area, it included origin and destination zones throughout the county. Following the survey, a preliminary major thoroughfare system map was prepared jointly by the city and county with the county undertaking co-ordination with various town officials.

As yet, it has not been adopted officially though portions of it, in the more rapidly developing fringe areas, are being put into effect. Rights-of-way are being dedicated by land developers through efforts of the city plan department. Until a source can be found for new right-of-way funds, the county cannot take advantage of planning for new or wider roads. It is anticipated that new funds for that purpose soon will be available.

Just what effect the greatly expanded federal highway construction program will have on county roads in this region is not known, except for one phase. The State of Texas is changing its long-time policy with respect to right-of-way provision. With legislation expected to be passed early in 1957, allowing condemnation, the state highway of itself will acquire the right-of-way on the interstate highways. That procedure will relieve counties—and Dallas County in

greater degree than any other—of this financial burden. Theoretically, the result should be to enable this County to build or improve more miles of county roads than heretofore.

The magnitude of the interstate highway system in Dallas is equalled by only one other city in the country. Upon its completion, expressways will radiate in every direction like the spokes of a wheel, augmented by a circumferential expressway. Then county roads will serve primarily as feeders to the expressways and to extensive commercial and industrial developments expected to locate adjacent to them.

In the nation-wide road-building program which lies ahead, the county engineer will undoubtedly be drawn closely into the planning phases. If proper co-ordination is secured between city, state and county planners, an overall net-work of highways of every type will evolve to serve the entire area sufficiently. The county traffic engineer can do his part in gathering and analyzing factual data pertinent to any planning phase.

County Traffic Engineering Staff

To cover county traffic engineering functions adequately does not require a large staff. True, a great amount of field work and travel are necessary but in average counties not entirely developed, one man can do a fairly thorough job. Actually more work is required in the field than in the office, where work principally comprises records and analysis of data collected, recommendations and survey reports.

If a relatively small number of intersections are signalized and new installations are done by contract, only one signal maintenance man on a retainer basis is required. A sign and marking crew of three men can handle all of that work and also set out traffic recorders. Accident records, accident spot map, counting machine tabulations and all files and correspondence can be handled by one secretary.

Budget for County Traffic Engineering

Quite naturally a county traffic engineer's fiscal requirements will not approach those required in moderately sized cities. Unless there are numerous intersections to signalize or an extensive signal system

to maintain, budget requirements are not high. An annual appropriation of $12,000 for materials and supplies will go a long way.

Obviously, when heavy equipment must be purchased—a paint striping machine, traffic recorders or a truck for transport—additional funds will be needed. But these items have a fairly long life. Another $25,000 to $30,000 annually will pay for personnel and transportation in this average county. Appropriations for signal equipment and maintenance will vary greatly with conditions.

Thus the annual outlay is meager in view of benefits to be derived. If tangible results are obtained in reducing accidents, injuries and deaths, the cost of the service is well justified.

Enforcement in the County

No one will deny that traffic control and regulations are wasted effort and expense if not enforced. Most counties, it is presumed, have a sheriff's department as the enforcing agency. In some counties, it may be the state highway patrol or local municipal police departments where the entire county is made up of municipalities.

Dallas County has an alert staff of deputies sheriff who patrol the county roads and also work in smaller towns where police are all but non-existent. Reporting of accidents is good, and on missing or damaged traffic signs. Frequently valuable suggestions are given for additional signs or regulations.

Enforcement of regulations is about as good as can be expected from any elected official. Naturally, an appointed chief of an enforcement agency can secure better results than one who must run for reelection every two or four years. This is simply a handicap under our county form of government, as compared with a city, that we must live with.

Amicable relations between traffic engineer and the enforcing agency are of course a necessity. The better the co-ordination between the two, the better the results that can be obtained.

Traffic Education

In this field the traffic county engineer can only lend his support in a general way. Newspaper publicity directed toward any accomplish-

ment in accident reduction is of course helpful. County residents can be counted on to take an interest in life- and property-saving methods as well as city people, if they are apprised of efforts in their behalf.

In Dallas County the traffic engineer takes an active part in an Annual Youth Safety Conference that is county-wide. The sheriff's office has assigned one deputy to work with all schools in the county area and small towns. He visits all schools, shows safety films and attempts to impress upon school administrators their responsibility in the movement of school buses and children about and near the grounds. Here again the traffic engineer can work closely with this enforcement official in providing signs and markings in the vicinity of schools.

Summary

The use of traffic engineering personnel and methods in urbanized or metropolitan counties should be encouraged. That service is needed to bridge the gap between municipal and state functions pertaining to traffic. Enforcement of a vehicle code applies to all streets and highways and it follows that engineering for traffic is a necessary adjunct. County engineers are kept busy with right-of-way acquisition and construction. They should have men who have specialized in traffic operation to consult on planning and take over details of safe and expeditious use of county highways.

Criteria herein described might well be studied by county officials in every metropolitan area to determine the need for a traffic engineer and the benefits that might thus accrue. If legal authority is required to accomplish the result, no doubt sufficient public support can be secured simply for the asking. Traffic engineering has proved itself valuable in cities and state highway organizations and it can do the same in appropriate counties, if given the opportunity.

To accomplish the benefits of up-grading county highways to a point where they will approach comparison in safe operation devices with similar state facilities is not an expensive undertaking. Tax rolls of counties in the category under discussion have increased sharply and funds no doubt can be made available to render such important service.

Population growth and its trend toward the suburbs call for careful examination of traffic requirements of the present and near

future. Use of the private and commercial vehicle is accelerating at a rapid rate. These are inescapable factors which county officials no longer can ignore. It is predicted that the next decade will see the number of county traffic engineers rapidly increase.

Scientific Fleet Management In the State of California

ELLSWORTH W. SCAMMON

Mr. Scammon is Chief of Automotive Management for the State of California. He is a career civil service employee and has held important field assignments in California government since 1935. As Minute Clerk of the State Senate, he became familiar with the legislative process and later transferred to field assignments with the Personnel Board, Department of Employment, War Manpower Commission, Reconstruction and Reemployment Commission, Governor's Office of Planning and Research and the Department of Finance. He was assigned to fleet operations as Chief of Automotive Management in 1950, and is currently responsible for the operation and repair of 18,000 state-owned vehicles.

MOST fleet management programs in effect throughout the country have much in common with Topsy—they "just growed." Relatively few large privately owned companies and an even smaller number of governmental agencies seem to be aware of the benefits that can accrue from scientific management of their motor-vehicle fleets, with the all-important end result of better transportation for less money.

Scientific fleet management has been slow in developing simply because nearly everyone who owns a motor vehicle has had some experience in the automotive field. He feels that personal knowledge gained over the years in trading vehicles, making repairs and in purchasing various automotive items qualifies him as an authority on the subject. Perhaps no other field has quite so many self-qualified "experts" as does the automotive industry.

Until 1950, operation of the state-owned fleet in California also suffered from Topsy-like growth and a lack of co-ordinated management. However, since the beginning in that year of a carefully planned fleet management program, operation of the state's fleet of motor vehicles has shown a marked increase in economy and efficiency.

The important role that fleet management plays today is illus-

trated by the fact that a saving of only one mill per mile in the operation of California's 18,000 state-owned vehicles represents nearly a quarter million dollars a year.

Some fundamentals of this program and the reasons for its success, include: Field inspection, which is the heart of the program; vehicle purchase and replacement; preventive maintenance; increasing the productivity of the worker; operation of automotive pools; cost-per-mile comparisons and reductions, and the urgent need for interchange of information on governmental fleet operations.

California's fleet management program received its initial impetus at the outbreak of World War II when motor vehicles were in short supply, yet essential governmental services required the furnishing of transportation that could not logically be accomplished by common carrier. A second impetus came during the war when continued operation of existing units required considerable maintenance. It was plain that vehicles would have to operate 100,000 miles or more before replacements could be obtained. Conservation became the order of the day and preventive maintenance began to receive some recognition.

Numerous separate agencies within the state government had their own vehicle supervisors, inasmuch as legal title of equipment rested with each agency; it was not until July, 1950, that the Automotive Management Section was authorized to provide central fleet management. Strangely enough, the underlying reason for establishing the section was not so much a desire for better fleet operation, but rather the necessity for controlling the misuse of state-owned cars by employees for personal reasons and home-to-office transportation. In an attempt to control such misuse, the State Legislature had passed certain directives and fiscal controls difficult to administer, and had directed the Department of Finance to carry out both the requirements and the intent of the legislature. Creation of the Automotive Management Section was the result.

Changing the pattern of daily transportation habits for thousands of state employees without disrupting the normal flow of governmental services, many of which required the furnishing of transportation, was an undertaking that could not be accomplished overnight with the passage of a legislative directive.

Travel patterns had developed over a period of several decades and in many areas of state government large numbers of employees had been recruited with the understanding, either expressed or implied, that state automobiles were to be furnished. Little consideration had been given to just how the vehicles were to be used. Yet overnight, all personal use of state vehicles was officially erased after June 30, 1950. Needless to say, everyone associated with this control program was at first considered to be a Simon Legree.

Administrative Controls Replace Legislative Controls

It was apparent at the outset that state governmental activities and the productive capacities of traveling employees would suffer unless immediate steps were taken to substitute workable controls for those set forth in the law. The State Board of Control, which governs certain internal "housekeeping" functions of the administrative phase of state government, was directed to adopt rules and regulations which would:

a. Define the use of state-owned motor vehicles which constitutes use in the conduct of state business and distinguish such use from misappropriation for private use;

b. Prescribe the procedure for determining and collecting from the employee responsible for misuse the actual costs to the state attributable to misuse of state-owned motor vehicles, and disposition of such collections;

c. Prescribe the records and reports to be kept and made by state agencies relating to the use of state-owned motor vehicles to the end that misuse may be discovered with a minimum of record keeping.

The legislature for the first time set forth in the Government Code policy statements that were guideposts for all to follow; yet the administrative procedures which would assure compliance with legislative intent were left to the administrative branch of state government to adopt and enforce. The Department of Finance was directed to administer the program, and the head or governing body of each state agency was directed to carry out and enforce the code provisions and Board of Control Rules and Regulations within such state agency.

The Automotive Management Section now had the responsibility for enforcement of vehicle misuse and for dissemination of this enforcement into each agency for control at the local level. With such assistance the Automotive Management Section then was able to direct its efforts into those fields where the tax-paying public could obtain more employee transportation for its tax dollar.

Automotive Inspection Program Inaugurated

With a state fleet then in excess of 12,000 units, many of which were owned and operated by agencies having little or no knowledge of fleet management practices, it had been required of all agencies to have those repairs amounting to $100 or more reviewed and approved by the Department of Finance. This requirement accomplished very little that was constructive and often did more harm than good by delaying urgently needed repairs.

When repairs of $100 or more were anticipated, the agencies were further required to submit three estimates; these, it was later determined, were many times prepared and submitted by the same repair shop on its own and two other repair shops' estimate sheets! Many estimates were submitted to "overhaul car complete" while on others the repair work proposed was not comparable on the three estimates submitted. Without an inspection of the vehicle, it was impossible to determine the validity of the proposed repair nor what would be accomplished with such expenditure.

To find a workable solution, two qualified mechanical inspectors went into the field to spot check, report their findings, and—more important—to give immediate Finance Department approval to needed repairs over $100 without the necessity of submitting three estimates to state offices in Sacramento for approval and return. Needless to say, much repair being accomplished was a complete waste of public funds. When approval for the proposed repair was withheld, or when approval was granted for a lesser amount of work, the agencies were indignant, to say the least; however, immediate field approval for needed repairs was received with much enthusiasm.

The inspection program was soon on its way to acceptance as more and more inspections proved to the agencies that not all state employees were experts in automotive repair or in diagnosing me-

chanical deficiencies. As a result, the program later was expanded to sixteen inspectors of automotive equipment, with the major portion of salaries and expenses supplied by the agencies from funds budgeted for maintenance and operation of the vehicles being inspected.

With the establishment of a field inspection program, it was possible not only to determine what repairs were needed, but also to establish better working relationships with repair shops and obtain proper fleet discounts on repair parts and flat-rate schedules for labor. It was at this point clearly discernible that, in nearly every instance, the dealer of the make of car to be repaired could make a better mechanical repair for the same or less money than other repair shops.

The requirement for three competitive bids for mechanical repairs of $100 or more was dropped, provided the dealer gave fleet discounts on parts and quoted flat-rate schedules for labor. It was also provided that the vehicle could be examined in the dealer's shop so that an accurate estimate for repairs could be made. Accident damage, because of variations in body and fender skills between shops, continues to require three competitive bids if the repair is $100 or more.

The automotive inspectors serve in the field to obtain needed information on any of the following:

1. Operating problems encountered by mechanical equipment.
2. Estimating the agencies' future equipment needs.
3. Application of motorized equipment to the job being done.
4. Adherence to the maintenance schedule by vehicle operators.
5. Recommendations for bettering various elements of the fleet in their respective areas of operation.

This inspection program is the most essential factor of fleet management as practiced in California. Because of it the total cost of transportation has been kept below five cents a mile for passenger cars notwithstanding the ever-increasing cost of equipment, parts and labor.

Vehicle Purchase and Replacement

All equipment is purchased through central purchasing in accordance with specifications prepared by the ordering agency and review-

ed by the Automotive Management Section. Passenger cars and pick-up trucks are purchased in blocks up to 1,000 units per bid with deliveries staggered over a period of several months at the three metropolitan centers of Los Angeles, San Francisco and Sacramento. Larger trucks and special purpose units are purchased on separate bids as they are needed.

Standardization, insofar as practical, is employed wherever possible; however, centralized purchasing and the general administrative policy governing purchasing practices make it impossible to standardize to the degree possible in private industry. Every business in California is a taxpayer and as such is entitled to do business with the state. Therefore, within reasonable limits, the price factor is given prime consideration and specifications for passenger vehicles and trucks are not unreasonably restrictive.

With but few exceptions, all replaced or surplus vehicles are sold at public auction rather than traded in on new equipment. A regular pattern of vehicle sales has been established and more than 90 percent of all sales are made to car dealers. A genuine effort is made to merchandise the old vehicles yet no used-car retailing is undertaken other than to clean the equipment and provide the prospective buyer with access to the lubrication and preventive maintenance record which has been kept with the unit through its full term of service.

This preventive maintenance record has been a major influence in obtaining prices for 100,000-mile cars that average better than wholesale book. Even more gratifying is the return of previous purchasers time and again because the need for reconditioning is usually less than for similar privately-owned cars with less mileage.

Why Preventive Maintenance?

Everyone knows that motor vehicles are made up of many mechanical parts assembled into various completed makes and models of units. What everyone doesn't know is that certain of these parts will need replacing or adjusting at various times. And no one knows just when such replacement or adjustment will be required. The objective in preventive maintenance, therefore, is to determine in advance what repairs or adjustments should be accomplished and at what intervals or mileages so that these services can be scheduled at

a convenient time and before the need for correction causes additional work or replacements.

A well-balanced preventive maintenance program will result in reduced cost of maintaining equipment, as well as other important bonus items. Dollar for dollar, the money expended on an efficient preventive maintenance program is returned in increased employee productivity because road breakdowns are kept to a minimum. With the average wage for a California state employee at $2.45 per hour, it is obvious that the loss of one or more days can equal the cost of a considerable amount of preventive maintenance.

The fleet's safety factor is also increased with periodic inspections which reveal needed correction or replacement of parts. Everyone is too familiar with the total cost of accidents to go into detail here but the prevention of just one accident might well pay the entire cost of the preventive maintenance program for a considerable time.

Exactly what is preventive maintenance? In its broadest sense, the term simply means a course of action designed to correct certain conditions before more extensive repair or replacement becomes necessary. This broad meaning is clear to most people, yet this definition cannot be universally applied because each piece of equipment must be considered as an individual unit, operating under its own set of conditions. We don't expect all people to give identical reactions to the same stimuli in different sections of the country, nor do we expect the health of the nation to be the same merely because the medical profession has outlined certain procedures for preventive medicine.

So it is in the operation and maintenance of automotive equipment. Certain fundamentals can be applied to the operation of all vehicles with reasonably satisfactory results, but many specific factors concerning the selection and operation of each vehicle must also be carefully considered. The procedures followed by California in its preventive maintenance program are outlined here not because it is thought they should be adopted by others, but because they are working successfully for California. One or two of these practices may open new avenues of thought for others interested in the field of preventive maintenance for fleet operations.

The purchase order for equipment is the first area that lends

itself to preventive maintenance. If the newly-acquired unit is not built for the job to be done, the need for maintenance of that unit can be a real source of trouble for the fleet supervisor. If the unit is to be retained for its full useful life, as it is in the State of California, we must weigh initial cost with all anticipated subsequent costs and be guided accordingly.

Some California Procedures

Matters of gross vehicle-weight, tire size, torque, gear ratio, and all other factors considered at the time of purchase must be given careful review. Three minor items have proved their importance out of all proportion to their initial cost. These are the high temperature (170 to 180 degree) thermostat, the heavy-duty oil bath air-cleaner and the oil filter.

After delivery, the equipment must be compared with the purchase order and invoice to determine that the unit received is the same as specified by the purchase order. The adequacy of predelivery service is also checked at this time because the operation of inadequately serviced equipment will certainly have its effect on the maintenance program at a later date. The 1,000-mile service is not made a part of the purchase order. Except for lubrication, which is paid for anyway, no additional service should be needed if predelivery service was adequate. The manufacturer's warranty will serve if any mechanical problem develops in the warranty period.

Regular servicing has done more to keep costs per mile within reasonable limits than any other single factor. In any fleet as large as this, it is imperative that minimum-service periods be established for lubrication and mechanical checks. Through laboratory analyses, review of mechanical records, and experience of trial and error, minimum standards have been developed. These are imprinted on a 2¼ by 2 inch adhesive label, as shown in Figure 1, and placed on the dash of every state vehicle.

This label constantly reminds the vehicle-driver that certain services are due at the mileage indicated. It is the driver's responsibility to have the services accomplished if he is in possession of the vehicle when the mileage is accrued. The sixteen inspectors of

automotive equipment assist in enforcing these minimum-service requirements.

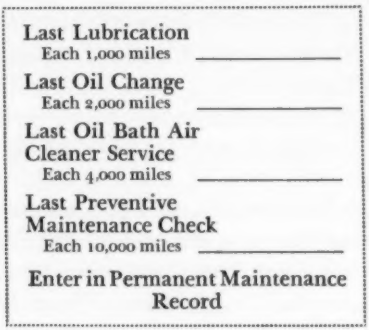


FIGURE 1. Minimum Service Standard

In addition to the reminder sticker, each vehicle carries a 32-page booklet (four by six and a half inches) entitled "Automobile Maintenance Record" which outlines recommended lubrication services and a suggested 10,000-mile safety inspection and preventive maintenance service. The major portion of the booklet is devoted to spaces in which each service performed must be recorded.

Within the last six years almost 100 percent adherence to these services has been attained, with a permanent record for each vehicle that can be checked by the inspectors of automotive equipment or the prospective buyer, when the vehicle is sold. This record is one of the reasons why the state's used equipment brings better-than-average prices and gives the prospective bidder an excellent indication of the general condition of the unit.

Accident prevention is an integral part of the preventive maintenance program. Prior to establishment of the Automotive Management Section, too little attention was given to the study of vehicle accidents or to the requirement that all accidents, no matter how minor, be reported to the Department of Finance. A pamphlet on defensive driving practices and the operator's responsibility—made available through the courtesy of an eastern refining company—was distributed to all state-vehicle operators upon recommendation of the California State Employees Accident Prevention Committee.

Also, a constant effort was made by this committee to have each accident report reviewed with the driver.

The favorable effect of both pamphlet and accident-reviews is reflected in the current standard premium of $26 per unit for $100,000 to $200,000 public liability and $10,000 property damage. This rate is subject to review at the end of the period.

The number of accidents reported in the first two years of this program actually increased because of a concerted drive to have every broken window and scratched or dented fender and body panel reported through channels on an accident report. Suddenly the physical appearance of the fleet improved as more and more field inspectors notified the operator's supervisor that an accident repair should be undertaken. Inasmuch as an accident report must accompany an accident-repair invoice before payment can be made, the responsible driver was required to furnish the report, even on minor accidents. The operator soon realized this procedure was more trouble to him personally than to drive defensively and avoid many accidents that would otherwise occur.

Attention was also directed to those agencies that considered minor dents and scratches a normal occupational hazard for that particular agency. In such instances, it was necessary to change not only the attitude of the vehicle operator but also that of the operator's supervisors.

A summary of all reported accidents was furnished to each operating agency and comparison then made. It was not unexpected that some of the highest accident ratios were attributable to agencies having the least exposure because of the occupational hazard. All agencies are now convinced that it is the personal responsibility of the vehicle operator to drive without accidents.

Non-Uniformity of Fleet Management Practices

Fleet management as practiced by tax-supported governments—whether cities, counties, special districts or states—is basically the same as that practiced by privately owned companies. However, additional considerations must be recognized by governments that could otherwise be discounted if the tax dollar were not the main source of funds for fleet operations. Taken as a whole, the taxpayer

LUBRICATION

RECOMMENDED LUBRICATION SERVICE FOR PASSENGER CARS, PICKUPS AND LIGHT TRUCKS

Number 1 Service—every 1,000 miles
- (a) Lubricate according to manufacturer's recommendations. Include the following:
- (b) Brake master cylinder, add fluid if necessary
- (c) Lubricate clutch release shaft (if applicable)
- (d) Fan—add oil if needed and applicable
- (e) Check steering gear housing, transmission (both standard and automatic) and differential, add lubricant if needed
- (f) Lubricate door hardware, use stick type lubricant on striker plates, wedge plates and dovetails

Number 2 Service—every 2,000 miles

Number 1 plus:
- (a) Change oil *
- (b) Clean and oil crankcase breather filter

Number 3 Service—every 4,000 miles

Number 1 and 2 service plus:
- (a) Service air cleaners *

Number 4 Service—every 8,000 miles

Number 1, 2 and 3 service plus:
- (a) Change oil filter element *

Number 5 Service—every 10,000 miles

Number 1 and 2 service plus:
- (a) Pack and adjust front wheel bearings, clean lining and report condition of brake lining and wheel cylinders
- (b) Fluid drive unit check fluid level (if applicable)
- (c) Pack covered springs

Number 6 Service—every 25,000 miles
- (a) Change automatic trans fluid in cars so equipped
- (b) Pack rear wheel bearings (if applicable)

EVERY SPRING AND FALL

Drain, flush and refill cooling system. Add rust inhibitor (not necessary to add if anti-freeze is used)

* When vehicles are operated in dusty air, oil changing, air cleaner servicing and oil filter element changing should be more frequent.

Cars used primarily for short trip driving with many stops and starts require more frequent changes of oil. The Department of Finance Automotive Management Section is prepared to assist in working out the proper lubrication schedule for any State facility operating cars in this manner. Inspectors are in the field contacting operators of State vehicles at all times. If you have a problem of any kind pertaining to the maintenance, operation or lubrication of State owned vehicles, please advise Automotive Management or the Inspector of Automotive Equipment who calls on you and assistance will be forthcoming without delay.

See Department of Finance Inspector of Automotive Equipment for forms for these services

SPECIMEN

FIGURE 2.

PREVENTIVE MAINTENANCE

Part 1 of 3

SUGGESTED 10,000 MILE SAFETY INSPECTION AND PREVENTIVE MAINTENANCE SERVICE

(Perform Yearly If Vehicle Runs Fewer Than 10,000 Miles Per Year)

AGENCY_____ DATE_____ (E)_____

Model Year_____ Make_____ Body Style_____ Mileage_____

LEGEND

Satisfactory √ **Repair or Adjustment Needed X**

Repair Accomplished (X)

ROAD TEST *(Should be made by Department of Finance Inspector of Automotive Equipment when possible)*		REMARKS *List work needed to correct operation of units marked X and approximate cost.*
1.	☐ Instrument gauges. Oil, fuel, ammeter, temperature, speedometer	
2.	☐ Horn, mirrors, W. S. wiper motor, blades and linkage	
3.	☐ Service brakes (braking effect, feel, side-pull, noise, pedal travel)	
4.	☐ Parking brake (adjustment, ratchet and pawl)	
5.	☐ Clutch (free travel, slip, drag, noise, chatter)	
6.	☐ Transmission (noise, staying in gear, free shifting, gear shift grommets)	
7.	☐ Steering (free play, bind, wander, side pull, shimmy)	
8.	☐ Engine operation (idling, power, acceleration, noise, smoke)	
9.	☐ Unusual noises (drive shaft, U joints, wheel bearings, tires, rear end)	
10.	☐ Rattles (body, fenders, chassis)	
11.	☐ Starter (action, noise)	
12.	☐ Heater, defroster (operation, leaks)	

If total charges for repairs found necessary during road test will increase the cost of this inspection by more than $50, authorization must be obtained from vehicle operator before any work is performed. Any minor adjustments, repairs or replacements may be made and charges added to the cost of the inspection without additional authorization.

See Department of Finance Inspector of Automotive Equipment for forms for these services

FIGURE 3.

PREVENTIVE MAINTENANCE

Part 2 of 3

TUNE ENGINE

	1	2	3	4	5	6	7	8
1. Compression Test								

If compression test indicates that ring or valve work will be needed before the next 10,000 mile inspection, *contact Department of Finance Inspector of Automotive Equipment* or operator.

2. Test battery, clean terminals, tighten hold-downs.
3. Clean or replace and adjust spark plugs.
4. Check distributor governor and vacuum advance.
5. Inspect distributor rotor, cap and plug wires.
6. Test coil and condenser.
7. Clean or replace and adjust ignition points, set timing.
8. Clean fuel filters.
9. Check manifold heat control.
10. Check carburetor throttle and adjust idle.
11. Adjust valves to factory recommended maximum clearance (overhead valve engines having adjustable rocker arms).
12. Check voltage regulator, adjust fan and generator belts, (on cars with equipment generator).
13. Check aim of headlights, adjust if necessary. Check all other lights.

Any repairs, adjustments or parts replacements related to this operation may be made and charges added to cost of tune up excepting installation of new carburetor, distributor, fuel pump or battery.

See Department of Finance Inspector of Automotive Equipment for forms for these services

SPECIMEN

FIGURE 4.

PREVENTIVE MAINTENANCE

Part 3 of 3

MECHANICAL

Inspect Condition of Parts Listed Below:

1. Check engine mounts, torque mount bolts.
2. Torque bolts transmission to flywheel housing.
3. Inspect exhaust manifolds, pipes, muffler and brackets for leaks and looseness.
4. Inspect rear axle and transmission for grease leaks at seals, transmission shaft, pinion shaft and wheels.
5. Torque axle U bolts and check spring shackles.
6. Inspect knee action, tie rod ends, king pins, support bolts for excessive wear, tighten lower support arm mounting bolts and steering gear housing at frame.
7. Check condition of tires.
8. Check action of shock absorbers, inspect shock for fluid leaks and tightness of mounting bolts.
9. Inspect cooling system, radiator core, freeze plugs, hoses, radiator and heater, also water pumps.
10. Check for engine oil leaks.
11. Check gas tank for leaks.

No parts are to be replaced in connection with this work without first obtaining authorization from operator.

See Department of Finance Inspector of Automotive Equipment for forms for these services

FIGURE 5.

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is interested primarily in providing the civil servant with adequate transportation at the lowest cost per mile, and the governmental fleet manager must always keep that fact in mind.

Transportation of the worker at the lowest cost per mile, however, cannot be the ultimate objective for the fleet supervisor. With ever-increasing personnel costs, it is imperative to conserve the employee's time and keep the employee as productive as possible. To establish a policy conducive to a lower cost-per-mile for needed transportation but reducing the productivity of the worker is not good fleet management. Practices which may be considered poor fleet management by certain standards may be quite necessary when viewed in the light of the overall operation. It must always be kept in mind that the fleet is but an operating tool with which to accomplish an objective.

The taxpayer rarely sees all sides of the picture. Neither does the company client. It is therefore the responsibility of the fleet supervisor to adjust his program to provide the greatest contribution possible toward balancing the operation of the fleet to the needs of his employer, whether a governmental unit or private industry.

In California State government, several basic methods are used to obtain transportation at the lowest cost per mile. The employee may be directed to use a common carrier—bus, train or air. In other instances, travel requirements may indicate that a mileage payment for the use of the employee's personal car is less costly to the state and is also acceptable to the traveler.

State equipment is used for all other transportation requirements. Travel by employees must be constantly reviewed. The fleet supervisor cannot administratively determine whether such travel is necessary; but he should be vitally interested in contributing to a lower cost per mile by furnishing the same vehicle requirements at reduced cost.

What constitutes a fleet management program? There are almost as many answers to this question as there are fleets of vehicles, because the foundations of fleet structure are predicated upon widely varying reasons for existence. The company that provides vehicles for its salesmen has different reasons for operating a fleet than does the public utility or similar organization having a service function to perform. Even within similar organizations, management policies

and directives may cause sharp changes in methods of fleet management, depending upon the objectives desired by top management. Almost without exception, however, the *cost-per-mile* factor receives prime consideration. Certain other fundamentals are uniformly practiced by most fleet managers.

The Establishment of Automotive Pools

With the enactment of legislative controls on the personal use of state vehicles in 1950, many highly placed officials found themselves without personal transportation for the first time in thirty years! When personal need for these state vehicles could no longer justify their retention, the automobiles became surplus to their official requirements overnight and the Department of Finance took over legal ownership. These surplus vehicles were then used for normal replacement of vehicles in lieu of new purchases or assigned to high-mileage drivers operating their own vehicles on a reimbursement basis.

Another condition became noticeable at the same time. Storage facilities for state automobiles were over-taxed, and although most vehicles were accruing the minimum requirement of 1,000 miles per month, these miles were often accrued in a very few days while the rest of the month the vehicle remained idle! The answer obviously was establishment of automotive pools wherever these conditions were found to exist.

As anyone having experience with a car pool knows, the idea of pooled equipment generally is not received with enthusiasm by those required to use the pool. Very few state employees believed that a car pool could be operated successfully. Moreover, a considerable number of others were determined that the pool would not be acceptable and did almost everything possible to prove their point. Nevertheless, the pool started with five vehicles and now has more than 1,200. In addition nearly all agencies are pooling their own vehicles wherever possible and making one car do the job where two or more had been used before.

Is the pool system working? The best answer is an opinion expressed by a department head who uses the pool in Sacramento yet has departmental cars in other parts of the state. He stated that the

overall condition of the pool vehicles—age, mechanical condition, appearance, and all other factors considered—indicates that pool cars are serving his department's needs better than department-assigned cars. This belief is shared by others and in many instances agency-vehicles have been voluntarily released to the pool by the owning agency because it was convinced the pool could better serve the agency's requirements.

If all things were equal, it should cost more to operate a pool of vehicles than individually assigned cars. A pool car, if free of mechanical faults and acceptable to all operators with their legitimate complaints, must be kept as close to mechanical perfection for its age and mileage as is economically feasible. It must be kept clean and it must be adequate to do the job demanded of it. This requires plenty of preventive maintenance. Each operator's complaint, whether actual or fancied, must receive proper attention. All this costs money, yet our total pool costs are lower than the average for the rest of the fleet.

Why is this so? First, the State's Automotive Section practices for its pool vehicles what it preaches to the agencies owning their own equipment—preventive maintenance.

Second, it has only as much equipment as it needs to serve transportation requests; this policy enables the pool to keep its equipment on the road rather than remaining idle. A vehicle that puts on mileage in the shortest time is the vehicle that covers those miles at the lowest cost per mile.

Third, the Automotive Section controls all expenditures on pool cars and not just those in excess of $100, as in the case of agency-owned vehicles. The major portion of maintenance repair is for work under $100; it is in this field that savings can be made when technically-trained employees are permitted to make a scientific diagnosis of the trouble. Over-zealous operators are soon found by pool management and a correction made, not so often in the vehicle, but in the eagerness of the operator to spend the state's money on unnecessary repairs.

Cost-Per-Mile Comparisons

Seldom, if ever, can the operating costs of any two fleets be compared because of variables somewhere in the operation. Either the work as-

signments of fleets are not exactly comparable or accounting methods do not allow for the same cost allocations in accounting records.

Even within the departments and agencies of California government there is usually some variable that makes accurate internal comparisons difficult. Fortunately, however, certain cost factors are uniform to all our state agencies. From these factors certain cost comparisons can be made which then indicate the areas that need further attention from the fleet supervisor.

The State of California has reduced its cost per mile for its passenger car fleet. How has this been accomplished?

First, almost anything that was done in 1950 would have been a move in the right direction. For many years, passenger vehicles were purchased one or two at a time and the used car taken in trade by the dealer receiving the purchase order. The make and model often varied with the importance or salary level of the employee requisitioning the car.

There were three inevitable results of such a method of operation: Standardization of make or model became impossible, the initial cost of equipment was higher than it should have been because the state's mass purchasing power was not utilized, and the price of the car taken in trade was usually discounted because it was usually not available for appraisal. If it was appraised, it was always presumed by the dealer that it would be in poorer condition when he received it upon delivery of the new car. The state now utilizes its volume-purchasing power and, in the main, merchandises its own used equipment.

Second, most operators either did not know how or did not particularly care about properly maintaining the equipment to which they were assigned. Preventive maintenance was haphazard among most state agencies and lubrication schedules were not taken too seriously. The automotive inspection program corrected that situation almost overnight, but results of improper maintenance during the years before inspectors were sent into the field remained for a considerable time before maintenance repair costs even approached what was considered acceptable.

Third, the accepted method of assigning vehicles to employees was a review of the anticipated annual mileage. An assignment was made if the employee was expected to travel 1,000 miles per month.

Highly placed officials were assigned a car regardless of the mileage factor. The legislative action prohibiting personal use of state-owned vehicles brought to light all those vehicles that did not accrue 1,000 miles of official travel per month. Furthermore, the daily-use report incorporated in the control portion of the legislation gave a good indication of why the vehicles were no longer required.

It took several years to adjust the travel requirements for state employees to a reasonable capital outlay for equipment and it is not expected that exact adjustment can ever be accomplished; however, capital outlay for equipment has been reduced because of a considerable increase in the average monthly mileage and days of use per vehicle. There has been a corresponding decrease in the average number of years a vehicle is retained in service even though there has been no change in the 100,000-mile replacement policy. That there has also been a decrease in the number of miles traveled for personal use is an understatement.

Fourth, by applying fleet-management practices to an operation that had received no central direction, based on scientific diagnosis for maintenance and repair, the cost of maintenance and operation was reduced.

The state pool was used from its inception as a pilot study to establish a norm for passenger-car and light-truck operation throughout the state fleet. By having closer management control over the state pool than over the balance of the state fleet, it was possible to inaugurate certain fleet-management policies for the pool and study the results before applying these policies to the entire fleet. This approach has slowly but steadily brought the cost per mile down each year for the last five years, even though operating costs for automotive transportation increased during this same period.

The State of California's budget for its anticipated fleet-costs per mile have remained almost constant for these seven years and the state pool has been able to reduce its cost per mile for each year except 1953–54. In the 1950–51 fiscal year, the cost per mile in cents was .0498; in 1951–52, it was .0496; in 1952–53, it was .0496; in 1953–54, it was .0499 and in 1954–55 and 1955–56, it was .0459.

It is believed that a further cost-per-mile reduction cannot be experienced without curtailing the efficiency of the traveling employee; however, constant endeavor is made to refine techniques

and adopt management methods that either hold down costs or provide for a better fleet of vehicles with no increase in the cost-per-mile figure.

All those experienced in fleet management will wonder what was included in that 1955–56 fiscal year pool-car cost per mile of .0459 cents. It is believed that every possible expense is included. Because the pool vehicles are used by practically every state agency, some of which are supported by a general fund appropriation and others by special funds, the state pool is required to include in its charges for use of the vehicles all items listed below:

1. Variable Expenses (incurred and accumulated through mileage traveled and therefore variable)			
a. Gasoline	¢.0162	or	35.3%
b. Oil	.0016	or	3.5%
c. Lubrication	.0015	or	3.3%
d. Maintenance and Repairs	.0081	or	17.6%
Preventive Maintenance			
P. M. Inspections			
Mechanical Repairs			
Tires, Tubes, and Batteries			
Washing and Polishing			
Road Service			
Miscellaneous (anti-freeze, chains, etc.)			
e. Accident Repairs	.0008	or	1.7%
f. Accounting Charges	.0010	or	2.2%
Personnel Overhead			
g. Management Supervision	.0006	or	1.3%
2. Fixed Expenses (Ownership without regard to mileage traveled and therefore fixed)			
a. Depreciation	.0100	or	21.8%
b. Storage and Rentals	.0042	or	9.2%
c. Insurance PL/PD	.0019	or	4.1%
d. Taxes and License Fees	None		
Totals	.0459		100%

On the basis of what gasoline will cost for the calendar year 1957 and that recent contracts for vehicles show an increase of more than $300 per unit over those purchased last year, the cost per mile should

increase to .0503 in 1957. As applied to the foregoing tabulation, the depreciation figure should be increased from .0100 to .0135 and gasoline from .0162 to .0172.

Need for Interchange of Fleet Information

Research is playing a more vital role in industry today than ever before and so is management specialization. Engineering firms, business consultants, and planning engineers are contributing more and more to industry and government. Practically every field of industry employs numerous management specialists.

In general, this does not hold true for fleet management in either government or industry. However, some large corporations are aware of the benefits of scientific fleet management and have adopted the basic principles of good fleet-management practice, with a desirable effect on economy and efficiency.

A few governmental agencies are also making excellent progress toward specialization in their fleet-management programs. But each governmental unit appears to be developing its own fleet program without benefit of the experience of other government levels or of parallel governmental units which may have developed similar phases of a management program, often by doing it the hard way.

A fleet manager must have association with other fleet managers or individuals dealing with problems of transportation. This he can do through the Society of Automotive Engineers by attending the section meetings on transportation and maintenance. The governmental fleet manager has another basic need, best met through associating with others engaged in management of governmental fleets. At present, this can only be accomplished through correspondence or personal visits, which limits the interchange of information to those who actively search for such material or who have sufficient budgeted funds to make possible a personal review of governmental fleet-management programs.

Exchange of information and ideas with individuals responsible for the same kind of government work in other localities can often produce valuable results in better methods of approach and more effective application of techniques.

Several localized fleet-supervisor groups have been formed for

mutual discussion and assistance. Yet no association exists for those responsible for managing large or small fleets of *governmental* vehicles. The number of tax-supported vehicles—excluding Federal—reaches into hundreds of thousands. It is strange that managers responsible for those vehicles have not banded together to report on their operations and discuss special problems for which there may be a ready answer.

It is hoped that those in the field of scientific fleet management for governmental vehicles can someday have a common meeting ground. Management programs can then be scrutinized by others in the same field for constructive criticism, suggestions and information to use in the best interests of tax-paying citizens everywhere.

Until such time as this common meeting ground can be found, California's Automotive Management Section stands ready to give and receive any information that will promote better fleet-management at all levels of governmental transportation.

Metropolitan Traffic Crisis

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TRAFFIC congestion is not a twentieth-century phenomenon. It accompanied urban centralization from the mid-nineteen-hundreds. Yet its present proportions are unprecedented. Its consequent inestimable economic loss presents one of the most vexing aspects of city planning. Despite the attention this problem receives, the outlook for any significant relief is not encouraging.

Vertical growth of downtown areas—intensifying the need for more movement to and from the central city core—apparent inability to supply sufficient transport arteries and mounting motor vehicle registrations, all augur no greater mobility for metropolitan traffic. The technological and economic difficulties attached to moving persons and property within metropolitan regions represent a most serious transportation crisis.

Some of the chief obstacles to acquiring a more smoothly functioning traffic network warrant a review:

1. *The Obsolete Structure of Cities*

American cities' basically rectangular street systems were not designed primarily to accommodate the flow of vehicular traffic. Streets are generally too narrow, especially when they serve the dual

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purpose of access and thoroughfare. There are too few opportunities for off-street parking and for loading and unloading commercial equipment.

Formerly it was essential to establish centralized districts for shopping, entertainment, and commercial services. These clusters were small enough to permit pedestrians to cover each. The need for this arrangement, given adequate accessibility by motor carrier, is no longer as great. Dispersal of these districts would obviate the necessity for bringing large numbers of people and supplies to relatively small areas; traffic and parking problems would be less acute.

It is apparent that decentralization of traditional downtown functions of shopping or banking—organized to depend on convenient access by automobile rather than by pedestrian—is rapidly increasing patronage. Such a reorientation of distribution methods, especially in view of the success of the regional shopping center, forces downtown commercial interests to aid in promoting new traffic plans (park-ride, bus fare, or parking fee refunds, etc.). In most cases, however, resources are lacking to alleviate the traffic problem effectively.

The modern city is not decaying, however. Perhaps some of its segments are. But with urban renewal programs these are already subject to reconversion of land uses. Ecologic necessity, accentuated by man's inherent gregariousness, will guarantee the large metropolis a foreseeable future, even though as a socio-economic entity its *relative* importance may be declining.

2. *Land Scarcity*

These structural inadequacies make any attempt to readjust the urban complex for achieving greater traffic mobility a formidable task. Not only is it technically difficult, but financially almost impossible to provide the highway arteries necessary for accommodating urban traffic. In the first place, not much land is available, and what there is is extremely expensive. Even for circumferential routes the cost is high. Second, added to land cost is the expense of relocating families, stores, and utilities. Furthermore, whenever urban land is converted from private to public use, a reduction in collectible property taxes results. Few communities are amenable to loss of income—though, in the long run, traffic relief may save municipal

outlays and ultimately increase real estate values which raise the tax base.

When it is finally possible to widen city streets, eliminate grade crossings, and increase traffic capacity, towns are apt to curtail the effectiveness of these improvements by permitting stores and services to develop along them. This policy obviously impedes the flow of traffic. Thus the use of roads for both access and thoroughfare continues to complicate the traffic dilemma when the need is primarily to divorce these two functions.

3. *Rush-hours*

The capacity and therefore the cost of a metropolitan transportation system is largely increased by the uneven demand for its use on a time-basis. It is generally estimated that in large urban centers forty percent of the total passenger traffic wishes to move within three hours or twelve and a half percent of the available time per day. To accommodate this demand often means that a six-lane instead of a four-line highway, or eight lanes instead of six lanes, are required. For urban land, the marginal cost of each added lane rises in geometric proportion to the initial lanes built.

The evanescence of transport services is their most costly aspect. While in some operations seasonal variations in demand provoke problems of use, none are as costly as those encountered by metropolitan transport facilities. This use-variation is necessitated partly by biological, partly by institutional factors—the preference for a nine-to-five, Monday to Friday, work schedule. Perhaps much more can be done to spread the work-day and readjust it more favorably in accordance with an individual's ability to perform. On the other hand, if this is accomplished, even greater use of the automobile in favor of more efficient alternate modes of transportation may be the result. This would only mean a prolonged rush-hour instead of a more balanced use of all available transport services.

4. *Inequitable Highway Finance*

The cost of major traffic relief-measures obviously represents a substantial financing problem. The problem is greatly, perhaps unnecessarily, aggravated by two important shortcomings that hamper larger cities. One arises from inequitable apportionment of

highway-user taxes collected by the states for urban use. This inequity is underscored by the fact that the city needs improvements the most, but because of under-representation, it receives relatively the least.

Intercity highway systems—and this applies to the allocation of federally collected highway taxes—are being developed much more rapidly, even though the immediate urgency rests within the metropolis. This means that not only is the city short of user-tax funds, but efficacy of the intercity road program is impaired because of inadequate terminal facilities.

The second major handicap for most cities is the debt limitation upon municipal finances imposed by the state. Thus, although proper plans are available, although in other respects the law may be adequate to permit land acquisition proceedings, or other prerequisites for providing traffic relief may have been met, the machinery for enactment is missing because funds are unavailable.

5. *Emergency Traffic Regulations*

The responsibility for coping with this situation is left to on-the-scene agencies. Their activities are generally restricted measures undeniably desirable in speeding traffic; but in the absence of more substantial relief, they can become not only annoying, but costly.

6. *Irrationality of the Motorist*

Finally the irrationality of the motorist contributes to the cost of urban traffic congestion. This is not intended to pass judgment upon human fallibility, but merely to point out that it is one reality of the problem. When assessing expenses per trip by automobile and by public conveyance, a true comparison is rarely made. Car travel today frequently requires no cash outlay—especially with gas station charge accounts—comparable to the purchase of commuter tickets or bus fares. This is a decided psychological disadvantage for the transit industry.

Automobile depreciation, insurance, licensing, or even maintenance may be overlooked in computing transportation costs when an individual uses private cars. Only when tolls and parking fees become a significant factor does resistance to automobile use become noticeable. But the American public prefers the private car. Costly

and deteriorating service on public carriers hastened the present trend, with growth in automobile traffic and decline in other uses interacting simultaneously.

Only in a few instances is the motorist willing to yield to a limited extent his prerogative to drive. To complete his trip, he may on occasion combine it with a bus or subway ride. But the temptation is usually to penetrate the city's complex as deeply as possible; and as long as he encounters no complete standstill, or restriction of private car use, someone will always try to occupy the last space available on city streets.

In addition to passenger transportation, the use of downtown streets by trucks and delivery vehicles is unavoidable. Consequently, many parts of today's city are made unsafe because ambulances and fire-trucks are denied speedy thoroughfare access and right-of-way.

Problems of the Transit Industry

With the implication that the cost of rehabilitating urban highway travel is high, that only a limited amount can be done to service the motor carrier, it is important that the problems and potential use of alternative transportation be further explored. Unfortunately, providing mass transport facilities is also complicated.[1]

1. *Initial Cost of Rehabilitation*

The neglect of mass transportation by most communities where it may be suitable for development of traffic relief, has unnecessarily enlarged the cost of rehabilitation. As long as carriers are financed privately, there is little hope of anything but further deterioration in service and higher fares on many suburban railroads, rapid transit (of which few remain in private hands) and some bus systems. Suburban railroad operations are currently sustained by earnings from other services, so these carriers are in several instances quite ready to abandon or drastically curtail suburban train schedules.

No financing of new rights-of-way, replacing of downtown terminals with new distribution routes, or addition of new stations, bridges, tunnels, and similar major undertakings, can be attempted

[1] The transit industry is considered here to include bus, trolley, subway and suburban railroad service.

with privately financed capital. Where such improvements are subject to additional local property taxes, the sale of capital, rather than addition to it, is encouraged.

2. *Motor Competition*

The private automobile has replaced numerous public service carriers. The interurban trolley was the first victim; railroad branch-line operations have been terminated in large numbers. Trolley cars were replaced by buses, but buses are losing patrons as are rapid transit systems and suburban railroads. The convenience of driving one's own car apparently cannot be matched under present circumstances.

However, it is not only motor vehicle competition; rising fares necessitated by greater costs have accelerated the trend from public to private, from rail to rubber-borne transportation. Higher fares discourage patronage; fewer schedules and less service result. More riders arrange for their own conveyance, and further losses in transit revenues lead to new requests for rate increases. While many public officials offer lip-service to promotion of the public carrier, in most cases they are relatively powerless to give it much substance.

3. *Operating Costs*

Only through sheer lack of an alternative and with much reluctance have cities taken over rapid transit systems, as in New York, Chicago or Boston. While authority operations have met with some success, noticeably in Cleveland, their impact upon the traffic problem has been comparatively minor. The powers granted to these authorities in coping with municipal transportation as a whole were perhaps insufficient. For example, no American city yet has an agency comparable to the London Passenger Transport Board which is capable of integrating all public carrier services for the entire London metropolitan area.

Financial Hazards of Transit Operations

There are, however, many good reasons for staying out of the transit business, public or private. As a public utility operation it shows characteristics which virtually doom it to financial failure. Most of

these apply to all forms of metropolitan transit.

a. The first of the general characteristics is that metropolitan passenger transportation is essentially short-haul, with a route density pattern consisting of light patronage at the outer end of the route and heavy concentrations of traffic for the downtown segments. This combination raises the cost of service per passenger-mile. Especially in railroad and subway facilities, where a large fixed investment is necessary for tracks, stations, yards and complicated signalling systems, little revenue remains to cover terminal expenses when the average ride consists only of a few miles.

The uneven traffic density along a typical metropolitan transit route—and this applies to all forms of transit—is perhaps even more serious. Whenever branch-line operations are involved, poor use of transit equipment becomes inevitable. Contrary to intercity traffic, almost all urban and suburban routes have empty seats at the trip's start, and fewer and fewer available seats as the center of the city is approached; standees are common for the downtown portion of the ride. Yet success in providing any kind of utility service rests upon good use or adequate load factors. Existing transit routes generally militate against a break-even load factor. On these grounds alone, bus companies frequently must rely on charter or other supplementary business, railroads on freight operations, and rapid transit systems on public subsidies, to carry on.

b. But this is only the beginning of the use-problem. The primary reason for idle capacity and vacant seats is of course the uneconomical peak to off-peak traffic relationship. The transit industry fares even worse than the metropolitan highway network in general, because there is a relatively greater incentive to use public carriers during rush-hours than at other times. During the day it is less trouble getting around in an automobile. On week-ends it is customary to take the entire family on a ride; an outing by bus or train is expensive and cumbersome, especially if a baby carriage or playpen has to be taken along. Furthermore, whenever new highway arteries are built or existing ones widened, they are likely to attract a greater proportion of off-peak rather than on-peak transit patrons. Consequently, the use-factor of metropolitan passenger carriers tends to get worse when traffic diversion takes place. This means that operations per passenger-mile continue to increase.

Poor utilization therefore accounts for the financial dilemma of transit lines.[2] Recognizing the possibility of inheriting a deficit undertaking, and already hard-pressed for income, a municipality or other public authority tends to avoid assuming transit services, yielding only under pressure from the dissatisfied commuting public. So far it cannot be finally established that the commuter's lot has improved as a result of shifting transit services from a private to a public agency, but one may assume that without this it may become much worse.

c. Additional reasons for high operating costs of transit services arise in part from *a* and *b* above. For example, suburban railroads have a particular disadvantage because suburban railroad properties are situated in areas subject to large real estate taxes. This is especially true of a downtown terminal. Even though the terminal services other than suburban passengers, it is often used by them more than by any other class of patrons. Taxes in this case are not merely an expense but also a deterrent to service improvements. Cities which levy such taxes, with due regard for their overall revenue needs, are taking a short-sighted point of view.

Encouragement of more suburban railroad-riders—by means of tax exemptions—may actually save them money by creating some street-traffic relief. Not only is such tax relief warranted, but cities served by railroads should aid in redeveloping the railroad's terminal operations. Instead of loading and discharging passengers at one location—thereby causing surface and underground congestion—a series of stops should be provided. Typically, the terminal commuter of today must continue his journey by bus, taxi or subway. Much of this could be avoided. But few municipalities seriously consider extending railroad service in this fashion. Where such measures actually are proposed, existing law and finances prohibit their enactment.

The rush-hour problem is aggravated also by complications of

[2] The author had occasion to examine the operations of the Long Island Railroad, whose main business is commuter traffic. If an equal number of daily passengers were to use the railroad each hour and in each direction over a 24-hour period, instead of about 40 percent of them riding during rush-hours as is now the case, then the railroad could get along with only 10 percent of its rolling stock and less than 25 percent of its manpower. In addition many fixed facilities would be made superflous. Yet the same number of riders as now could be accommodated.

manpower scheduling. Unfortunately, the span from the beginning of the morning rush to the end of the evening peak is longer than eight hours. Unless operating crews and drivers are willing to accept split shifts without overtime pay scales, operating costs are unavoidably increased. Poor utilization results not only in idle equipment but also in layover personnel.

Suburban railroads are badly affected in this particular, because their crews are generally subject to operating rules established by the railroad brotherhoods for passenger service as a whole. No special recognition is given to the peculiarities of suburban service and its inherent scheduling difficulties. Much of a railroad's problems here could be alleviated if it were possible to allow available trainmen to do other work between rush-hours. To some extent this principle is in effect where bus drivers are willing to do maintenance work at times when they are not needed to operate their vehicles. Unfortunately, existing realities make these suggestions merely wishful thinking.

A singularly disadvantageous feature of bus transport today, which raises its cost and reduces its service-value, is frequent delay in traffic congestion. This ties up equipment and drivers, adds to congestion, and not only slows up service but makes it more difficult to maintain regular headways between buses. Undoubtedly, this has been a major factor in loss of bus passengers. There are numerous devices which might curtail interference with bus transit operations, but they have not been exploited as widely as possible.

The Transit Fare Structure

Rates charged to transit patrons often have little relationship to costs of service. This is especially true of commuters or peak-riders who account for a different set of costs from customers who want service at other times. For most utilities it is customary to enact a demand-charge against those responsible for the size of the plant in the first place, namely the peak-users. By this method better use of all installations is encouraged and a lower per unit cost of service obtained.

The transit industry has no demand-charges. In many cases, for the sake of convenience, there is merely a flat charge, with no dif-

ferentiation as to length or time of ride. In other cases zones are designated to allow for differing distances traveled. But the fare structure has no influence on the use-factor of the transit company. To encourage greater patronage in the outlying districts, for example, intra-suburban fares could be adjusted so that the fare per mile is less along low density segments of a route than where traffic is usually heavier.

The biggest anomaly, however, exists where fares actually encourage peak ridership and in effect discourage those wanting to ride during the off-peak periods. This occurs where tokens are offered at a discount over the cash rate for a specified number of rides. It is the regular rider, the commuter, who takes advantage of such a fare scheme when, in terms of cost, it is he who should have the highest demand-charge assessed against him.

The most irrational of all transit-fare structures exists on suburban railroads. Here, commonly, the peak-rider pays one-half or less of the standard fare paid by the occasional or off-peak traveler. Although some carriers have experimented more or less successfully with special shopping, theater, or week-end tickets, their price generally remains higher than that of commuter tickets on a trip or mile basis, so the basic deficiency remains. Much needs to be done to encourage off-peak use, although other devices are necessary to shift a large portion of rush-hour travel from highway to railroads or subways.

It is difficult to explain why, in the light of better understanding of utility pricing-practices in general, inadequate fare structures are permitted to continue. Unquestionably, they have a historical basis when railroads and former inter-urban lines were first interested in populating suburbs by offering special fare inducements. Since then, it may be argued that stringent regulation was responsible for preventing fare adjustments in accordance with service costs.

As long as railroads have sources of income substantially in excess of those represented by their suburban passenger business, such policy by the regulatory agencies, upheld by court decisions, is likely to continue. In preventing any further erosion of rail commuter-traffic in favor of automobile traffic, such a policy may have been, perhaps inadvertently, a wise one. But in the meantime, as long as railroad passenger-operations are conducted on the basis of

non-compensatory fares, the railroads cannot be expected to make major contributions toward relieving metropolitan traffic chaos. This responsibility lies elsewhere.

It is not difficult to give an impression of hopelessness in reaching for solutions to existing traffic conditions. One of the principal reasons for apparent futility in acting on the traffic problem stems not from the economic and technical obstacles already pointed out, but from the existing institutional framework within which we must operate to get anything done at all. The consequences of this needless waste can hardly be estimated. For simplification, this may be described as lack of co-ordination which takes primarily two different, though related, forms:

Obsolete Political Structure

The multiplicity of governmental units taking part in the traffic dilemma, sharing the responsibility for solving it, gives eloquence to the adage: "Too many cooks spoil the broth." Primarily because of legal limitations, divided jurisdictions, and artificial political boundaries, modern cities have inadequate transport.

To illustrate, the immediate needs of traffic flow are generally assigned to police or traffic departments. This means that each urban and suburban community independently acts on a home-rule basis. The government of one county may get neighboring communities within its confines to agree on policy concerning traffic relief. On the other hand, it may differ from adjoining counties. Where there are three levels of local government—village, town and county—the chances of conflict are increased.

The states, apart from regular highway or public works departments, provide special parkway commissions and bridge and tunnel authorities. These sometimes help to reconcile diverse local interests, and they may get a job done that otherwise would have been impossible. Governments also set up advisory commissions at all administrative levels, *ad hoc* committees to look into a particular traffic problem, and numerous planning commissions.

In addition, many non-governmental units work to promote better transport conditions. These include chambers of commerce, the carriers themselves, safety councils, numerous industries and a

host of civic organizations. There is without doubt widespread interest and activity in the traffic problem. This effort has often resulted in effective relief measures. On the other hand, the very diffusiveness of these groups makes it impossible to integrate all aspects of the problem and to come up with a long-range solution.

The enactment of proposals involving major capital expenditures often is delayed or rejected, not because they are unsound but because machinery for putting them into effect is lacking. Many fine plans are gathering dust because of this.

Without integration in the planning of substantive traffic relief measures, existing conditions may actually become worse. This happens when one community is able to shift a traffic bottleneck to its neighbor, when a new by-pass is terminated at a county line, or when programming does not schedule the most needed facility first. Having one community gain at the expense of another is of course no solution. Lack of proper co-ordination may also result in enacting faulty measures which may subsequently have to be corrected causing needless expense. Another cost factor arises from duplication of effort when singleness of purpose should prevail.

The absence of a regional approach to metropolitan problems is not only true of transportation requirements, but of most other municipal services as well. But transportation, in view of its particular fluidity needs, is perhaps the most obvious to defy purely local administration. Under existing circumstances, it is impossible to deal adequately with the metropolitan transportation problem, that is, to curtail the present economic and social loss.

The current administrative setup does not permit any perceptible increase in the mobility of people and goods throughout metropolitan regions. The immediate task of obtaining better transport conditions for our cities rests primarily on the public administration expert, the political scientist. He must help to furnish an apparatus that can bring about the most rational and successful attack on the traffic problem.

The Absence of Functional Integration

Lack of administrative machinery and resulting deficiency in the co-ordination of effort do not constitute the only obstacle to a re-

gional solution of the traffic problem. Another serious and perhaps more subtle difficulty has to do with reaching a greater measure of agreement—integration—among those directly in charge of improving present conditions. This defect is functional rather than administrative. For in dealing with traffic congestion, three schools of thought prevail.

The first believes that building expressways, tunnels, bridges, or by-passes supplies the logical remedy. It holds that the rising flood of automobiles must be accommodated at all costs.

The second group is primarily interested in punitive and restrictive measures. It prefers to assess a greater share of the motorist-induced expenses directly against the culprit. It would eliminate "unessential" vehicles from downtown areas; enact special tolls for entering congested parts of a city; change existing traffic patterns by putting into effect more one-way streets; eliminate parking at certain locations, etc.

The third approach concentrates upon improving alternative means of transportation: buses, subways, railroads, or any other proposal for improved mass transportation (unibus, monorail).

All of these preferences have merit, but they are rarely considered jointly and adjusted so that each may contribute to the best of its respective capacity. Especially the third alternative, public transportation improvement, warrants more attention whenever plans are contemplated for a new bond issue to cover the cost of a major highway facility, or for rerouting of traffic. The impact of a rail transit fare increase, for example, must be similarly weighed in relation to its potential effect upon existing highway traffic conditions. The three schools of thought require a much closer relationship than they receive at present so that all efforts can be channeled conveniently along the most productive route.

Regional Transport Agency Suggested

It may be presumptuous to offer recommendations purportedly resolving one of our most complex economic, technological and administrative problems. Yet numerous measures suggest themselves for increasing the rate of the metropolitan traffic flow.

Foremost among these is the necessity for establishing a regional

agency having sufficient jurisdiction over an area to carry out an integrated program for transport improvements that will result in the greatest benefit for the least cost. The geographical delineation of such an area must consider existing traffic patterns by examining origin-destination counts of existing commuter and freight transportation. These data will give a convenient basis for establishing a more realistic concept of a standard metropolitan area. Enough of a fringe should be included to allow for future expansion.

An authority, board, or commission of this nature must be supported by user-charges, such as tolls and fares, as well as by local taxes and state and federal aid. It must be adequately financed and organized so that it can attack the problem to take advantage of the most economical and technologically feasible plans available in each case. Its activities must include all phases of metropolitan traffic, including construction of vehicular facilities, traffic regulation, and supervision if not actual operation of public transit.

If it does not operate transit systems, the regional agency should be responsible for financing necessary capital improvements of transit facilities which in turn may be leased to a private operator. Bus service could be continued in most cases as at present, but companies should be exempt from all local taxes. In return they should be subject to the jurisdiction of the regional authority with respect to schedule frequency and location of routes, so that maximum coordination of all services can be attained.

There are many advantages to the establishment of a regional transport agency:

1. *Influence of Land Use*

Since transportation patterns affect the uses of land, a regional agency would be in a key position for reaching decisions that would result in more economical development of the area under its jurisdiction. Adequate transport planning would at the same time promote balanced community growth with respect to industrial, commercial, residential, recreational and other activities.

Lack of orderly development at the moment seriously concerns those communities where the need for local taxes to finance municipal services, especially schools, cannot be met adequately. Furthermore, a regional approach to the transport problem would permit

the channeling of decentralization so that it would somewhat curtail the necessity to travel long distances by bringing a larger selection of employers nearer to commuters' place of residence.

2. *Influence on Travel Pattern*

A regional authority would be in much better position than existing organizations to encourage a shift from rubber to rail transport, where the latter is clearly the most efficient in handling large numbers of commuters. Under modern conditions it is possible to move at least 35,000 seated passengers per hour per track on railroads or subways with a minimum of space to accommodate these.

The authority could assess more equitably through a system of tolls the cost of servicing vehicular traffic in downtown areas than is now the case. It could reinvest its earnings more readily into those facilities most needed and make sure that highway widening or new construction would not end at a point that merely shifted traffic congestion from one area to another. It could adopt a priority system based on need, where the need is established after hearings of all interested parties have been held.

3. *Service Co-ordination*

Co-ordination of metropolitan transport services is possible only if a regional structure is followed. This is vital if service improvements are achieved to induce more persons to avail themselves of public carriers. With such co-ordination, mass transport agencies will have a better chance of giving the service they are best equipped to handle instead of seeking survival on a makeshift basis.

For example, buses could be more effectively used by extending their operations as feeder lines; they could improve joint services with railroads and subways. Much remains to be done in relocating suburban railroad stations. Some of them should be removed from their present sites, especially where they add to local traffic bottlenecks and where there are no grade crossings. Instead, new station stops could be provided where large parking areas and easy access are available. The idea of rapid transit shuttle service—or for smaller towns, bus shuttles—from an outlying parking lot to the heart of the business district appears to have some merit.

For the convenience of patrons, a single administration would

further the possibilities of joint scheduling and ticketing among different classes of carriers. This lack is at present a most conspicuous defect.

4. *Rate Structure*

Apart from service improvements, an integrated, region-wide transport system could develop a fare structure which would promote better use of services provided. Such fares must consider incentives to use low-density segments of any route, off-peak travel, and passenger movements going in the opposite direction of the main rush-hour flow. This means specially low fares for each of these services.

But peak fares must also be adjusted to encourage maximum transit use, whenever this policy helps to cut the cost of rush-hour highway congestion. Thus peak rates should not be based on the fully allocated costs of furnishing such service alone, but on an estimate involving the *total* cost of providing rush-hour operations by all types of carriers and vehicles. If a subway ride, for example, discourages patrons so that they go by car instead, then the subway rate is too high, for its cost is lower than the cost of accommodating the motorist.

It is indeed a complicated task to establish transit rates and automobile-user charges so that a distribution of traffic among the various carriers would result in the lowest overall cost. But under existing conditions the two are not at all considered jointly. Unless this is done, there is little hope that each transport agency will be able to demonstrate whatever inherent advantage it possesses, and that existing costs of furnishing metropolitan transport services can be lowered. A regional agency would be in a much improved position to adjust revenues and costs for optimum results.

5. *Public Policy*

The agency proposed here might also more effectively acquaint the public with costs and problems of urban traffic congestion. A transport authority might encourage employers to stagger working hours further for their personnel, so that rush-hour crowding may be reduced. It could promulgate the advantages of each mode of transportation and the respective costs involved in their use.

Through an effective public relations program, metropolitan travelers could become better informed on the reasons for high automobile insurance and depreciation rates, the convenience of alternative services, and the savings to the community as a whole in choosing more economical modes of travel. Much needs to be done to acquaint residents of the metropolis with existing operation of public carriers.

Another educational function of a regional transport agency would be to request a more just basis for refunding municipally collected highway-user taxes by the state and federal governments. This step is most vital if needed structures for a regional improvement program are to be obtained. Furthermore, such an agency could integrate urban transport needs with those of the intercity highway network, a goal that would greatly increase the utility of the federal highway construction program now under way.

While a regional organization should have powers enough to do the things outlined above, it is not suggested that a form of "supergovernment" be created. On the contrary, there must be enough safeguards to keep it from assuming responsibilities in excess of what is prescribed for obtaining a proper transport system. Its tolls or fares, for example, should still remain subject to public utility regulation by each state involved, or, where appropriate, by the Interstate Commerce Commission. The power to condemn property must be granted only with adequate controls to prevent abuse. Before existing transit services are turned over for operation by a commission, it must be conclusively established that public control is preferable to private operation. Thus legislative and judicial checks must remain to prevent undue centralization of authority.

But this task is one for specialists and ultimately the legislature to work out. The purpose here is merely to point out the need for whatever machinery is necessary to improve what is now available and to avoid duplication and waste of effort.

Undoubtedly, a proposal of this sort will draw criticism, especially when a degree of autonomy is to be yielded by existing political units. County governments will be jealous of losing some of their home rule functions. The creation of a regional transport board must in any event go to the voters first, so that issues may be widely discussed, formulated and clearly presented.

Traffic Relief Needs Broader Planning

Under present circumstances, transport resources are tied up and expended needlessly in our large cities and their surroundings. What this means in municipal costs, local taxes, real estate values, labor mobility, market competition, and civil defense, not to mention the wear and tear on the human being caught up in this maelstrom, need not be discussed here. The chaos is plainly visible.

If traffic relief is to come, regional thinking is a prerequisite. In view of the rapid growth of metropolitan areas, an articulate transportation system is indispensable if existing or rising standards of living are to be maintained. There are encouraging signs that the urgency of adequate relief is being recognized. The recent Mayors' Conference sponsored by the City of New York is an example; there are many others throughout the nation.

Planning on a regional basis does not apply to transportation alone. A co-ordination of effort must extend to all metropolitan needs. The combination of urban renewal programs with the location of new transport arteries has already been suggested. Many more opportunities abound for joint programming; transportation is not the only issue—it cannot be tackled without regard to other needs.

This raises one final question. Even though traffic congestion today may be producing a staggering economic loss, capitulation to motordom may not for the moment be the most desirable social objective in the light of other needs. Apparently, the motorist is willing to put up with a lot. If he insists on driving, perhaps unaware of all the consequences, it may be validly asked whether his accommodation should rank ahead of delinquency, alcoholism, petty crime, inadequate schools, and other welfare problems. Each issue, therefore, must be dealt with in its relationship to a properly evaluated scale of needs.

Highway Program Needs Support

J. EDWARD JOHNSTON

Mr. Johnston is Highway Transportation Specialist for the United States Chamber of Commerce. From 1925 to 1940, he did general highway engineering for the Nebraska State Highway Department, and for the next twelve years was Traffic Engineer for Nebraska. Mr. Johnston was also manager of the highway department of the American Automobile Association, and later, of its traffic engineering department. He holds the degree of Civil Engineer, a certificate from the Bureau of Highway Traffic at Yale University, and is a Registered Professional Engineer. He has lectured on traffic engineering at the University of Nebraska and at the National Institute for Traffic Safety Training of Northwestern University. Former chairman of numerous committees of the Highway Research Board, the National Safety Council, and the American Association of State Highway Officials, Mr. Johnston is also a member and former Director of the Institute of Traffic Engineers, the American Society of Civil Engineers, and of the Washington Section of I.T.C.

LIKE the boy who found under his Christmas tree a new band instrument he had dreamed of owning, the nation is gradually realizing that a national system of interstate highways and other greatly needed highway improvements can become a reality. But the band instrument does not make the boy a musician nor will the $27.4 billions authorized by Congress for road-building provide the country with such roads without the active support and efforts of every segment of our great population.

Our highway leaders have fought long and diligently for better roads and particularly for an expanded federal-aid program that would insure an interconnected network of highways vitally needed for interstate commerce and national defense. When they found the Federal Aid Highway Act of 1956 gave them essentially everything they had been striving for, even many highway leaders found it difficult to realize the import of what had happened.

Like the attack on Pearl Harbor that memorable December 7th when it was difficult to convince the crews of our Pacific Fleet that the attack was real, America today finds itself in a mild state of shock

as it faces the road-building task ahead and the problems confronting every state and city before the last mile of the 41,000-mile interstate system is completed.

It is desirable to see how the 1956 Federal Aid Highway Act differs from previous legislation. The important change for federal-aid roads other than those on the interstate system is in the greatly increased amounts authorized for expenditure. In the 1954 Act, Congress authorized only $700 million for each of the fiscal years 1955 and 1956 on these regular federal-aid roads. The new act authorized $825 million for 1957, $850 million for 1958, $875 million for 1959. Provision for three years was made instead of the customary two years. The federal government will match state funds on a fifty-fifty basis as has been done since the first Federal-Aid Act was passed in 1916.

New Concepts in Highway Legislation

The greatest difference is in the recognition of the interstate system. Congress recognized this system not as a part of a program but as a thirteen-year project. It not only authorized the funds needed to complete the project within this period but provided for financing by earmarking current and newly imposed highway-user taxes deposited in a highway trust fund. Congress had traditionally regarded excise taxes on gasoline, motor vehicles, and motor vehicle accessories as general fund revenue, having no relation to the amounts authorized for federal-aid road building. The new act is an about-face on this policy, although it should be pointed out that only about two-thirds of the current automotive excise taxes are being deposited in the highway trust fund.

The project foresees a completely interconnected system of controlled access, dual-lane, divided freeways, extending the length and breadth of the United States, without traffic lights and stop signs. The system will connect 90 percent of our cities having more than fifty thousand persons and will carry 20 percent of the traffic.

The new thirteen-year project for construction of the interstate system will make possible long-range planning by engineers, planners, contractors and manufacturers. The previous biennial authorizations gave no assurance of more than a two-year program.

Another change is that the federal government will pay 90 percent of the costs, with local governments paying only 10 percent. Some people ask why the federal government should assume such primary responsibility. Only the federal government can assure a completed, uniformly designed national system of highways. Since the interstate system was designated in 1947, progress made in its completion has proved that without a more than normal stimulus from the federal government it would take from fifty to seventy-five years to complete and even then there could be no assurance of uniform standards of design—including access control. Large and small corporations build automobiles, airplanes, boats and railroad trains, but no private enterprise can effectively create and operate a national system of highways.

The requirement that the interstate system be built with access control departs from previous federal-aid policy. Access control will be required on all except a very few miles of the most sparsely settled areas and even then on a most restricted basis. History will praise the wisdom and fortitude of our Congressmen who supported access control principles in spite of much determined and organized opposition from many of their constituents. Only through use of access control can an efficient and safe highway transportation system be constructed that will insure the sound expenditure of public funds and avoid the necessity of expensive reconstruction in later years. Contrary to the belief of many businessmen, access control has proved a benefit to most individual businesses and to the community as a whole.

Another important feature of the act provides for public hearings to be held wherever federal-aid highway construction is proposed through or around any incorporated or unincorporated urban areas. These public hearings are twofold in their importance: first, they give state highway departments an opportunity to explain the highway program to the public; second, they provide an opportunity for the public to express its views on proposed route locations. The state highway department must certify to the Bureau of Public Roads that it has held public hearings or has afforded the opportunity for such hearings. If hearings are held, a transcript of the proceedings must accompany the highway plans submitted for approval.

The manner in which funds will be apportioned to the states is

another significant departure from previous federal-aid highway acts. Formerly, the apportionment formula was based on the ratio that each state's area, population and postroad mileage bore to the total of these factors in the United States. The 1954 Act slightly modified this procedure—basing half of the apportionment on the traditional formula and the other half on one in which population alone was used.

During the first three years of the program, the 1954 formula is being continued; Congress has expressed the intent, however, as soon as a state-by-state need for the interstate system is carefully reappraised, to base all apportionments thereafter on needs alone including readjustments for amounts received during the first three years in which the formula was applied.

Another far-sighted provision is made in the act. Advance rights-of-way can be purchased by the states out of interstate funds so long as construction is started within five years after such purchase. Furthermore, where states do not have the power to control access, the federal government can purchase property for highway purpose and insure access control by withholding the outer five feet.

These new concepts in responsibility, design standards, financing and administration must be well understood by the public if this gigantic program is to get off the ground.

Benefits of the Road Program

Most businessmen will be affected either directly or indirectly by the road-building program. More rapid and economical transportation of materials and merchandise will be realized early in the program as soon as sections of new or improved highways are completed. There will even be a rush by many businessmen to re-locate their businesses and industries near the new roads.

As new highways continue to expand the convenient horizon of travel, intervening miles will become less and less an obstacle to the shopping habits of the American public. Additional miles of travel generated by improved roads for automobiles, trucks and buses will have considerable impact on gasoline stations, restaurants, and motels to say nothing of the petroleum and automotive industries.

With careful planning, the new freeways and expressways can

become the guiding force in urban redevelopment and expansion of our cities; more economic use can be made of urban and suburban land for business, industry and dwellings.

Although many of the benefits will be long-range, immediate benefits will come to the highway construction industries. This program will create need for more cement, aggregates, bituminous, steel, concrete and road building equipment. Hundreds of thousands of employees working on and off the site of these projects will create employment and payrolls that will help to continue and prosper our present national economy.

Roadblocks to Progress

We have in the past been prone to sit back and let our highway officials struggle with road and street problems. It might even seem that at times the public made the job as hard for highway officials as possible. This attitude will not build our country's highways.

Some have opposed an expanded federal-aid program from the beginning. Many will oppose road locations, particularly when their businesses are by-passed or cut off from access to the highways by access-control.

It should be clear that all highway improvements cannot run past the door of every business. To support a program in which some businesses may be uprooted and where even entire communities may be by-passed, requires a far-sighted, civic-minded business community—one more interested in general welfare than in immediate gains.

In every community there will be differing opinions on which road should be built first, on its capacity and location. None is better able to break the bottlenecks that confront every public official in this program than the organized local businessman speaking through his chamber of commerce and other civic organizations.

As never before, sound planning and intelligent leadership are needed to locate new routes where they will do the community the most good in its over-all planning, and handle its transportation requirements. Those cities will benefit the most where planning can be done early during the program because they will be the first to receive the new facilities.

State highway departments are the key agencies in implementing the program. To determine views of highway officials regarding cooperation with local businessmen, the United States Chamber of Commerce sent out inquiries to state highway officials. The following are a few of the replies received:

What Highway Officials Say

C. R. McMillan, Chief Highway Commissioner of South Carolina, said, "Although we have been given the necessary funds and authority to go ahead with the stepped-up program, we cannot successfully carry it out without public support. We realize that the support of businessmen is essential since it is with them that we will most often have to negotiate in obtaining rights-of-way, access rights."

From California, Frank B. Durkee, Director, Department of Public Works, said, "I should like to express the gratitude of the Commission for the stand which has been taken by civic organizations in recent route adoption discussions. These bodies, along with the planning commissions and other public-spirited groups, have taken the trouble to inform themselves of the facts—all the facts—involved in the selection of a recommended route, and often have endorsed the proposal of the state highway engineer in the face of severe criticism by individual citizens or newly-formed protest organizations."

In referring specifically to two chambers of commerce, R. R. Bartelsmeyer, Chief Highway Engineer of Illinois, said, "The Joliet and Mattoon Chambers of Commerce were felt to be the strongest local forces in instigating and promoting the completion and acceptance of transportation and street development plans in those cities. These two are mentioned only as the most recent examples of the uniformly fine support which we have enjoyed from such organizations."

Mr. Bartelsmeyer's comment referred to all types of transportation and street development plans.

Eugene M. Johnson, Chief Engineer for Mississippi, made an important comment: "The Federal-Aid Highway Act of 1956 requires public hearings. The tendency of such hearings will probably be for opponents to appear in numbers. The chambers of commerce could

see to it that proponents are present also. It is my opinion that chambers of commerce could be of great service in this respect."

Although most of the replies praised the support chambers of commerce have given to highway officials, several replies did not. One in a mid-western state said, "Most chambers of commerce take a very dim view of any highway development which will not benefit their particular community. Even though the construction of the interstate system will benefit the state as a whole, chambers of commerce generally are very reluctant to get behind this proposal unless they can see that the interstate system will either directly benefit their community or be located in such a manner that traffic will be attracted to their immediate area. . . . I feel that chambers of commerce need to be sold on the tremendous impact of the expanded highway program on each of the individual states and on our nation as a whole."

Another disheartening report came from a chief engineer in an eastern state: "I am sorry to report that I could not discover one single instance where local chambers of commerce have been of any help in our highway improvement program and found only further instances of obstruction which I did not know about personally. . . .

"The greatest opposition from local chambers of commerce stems from opposed bypasses. There is a real need for co-operation and a foresighted body of men such as chambers of commerce toward enlightening the public as to the advantages to be derived from modern highway construction. Yet I believe these very same men, who we feel should be able to be so helpful, need enlightenment themselves."

In addition to questioning highway officials, information was solicited from a number of chambers covering various population groups as to the kind of highway program they had been carrying on. In summarizing these replies, the following objectives and the manner in which they were implemented stood out.

Objectives of a Highway Program

One of the first and most important objectives should be to develop aggressive community leadership. Businessmen are the backbone of every community. Whenever there is a civic good to be accom-

plished—whether in building public improvements or in raising funds for charitable activities—one invariably finds businessmen spear-heading the movement and doing most of the work.

Chambers of commerce throughout the years have fought for good roads, not only for those that immediately benefit them but for those that benefit the community, county, and state as well. The citizens of each community need aggressive community leadership to bring to reality an adequate, efficient street and highway system.

Next, the objective should be to provide informed, well-advised guidance to federal, state, county and city highway officials. Comments from state highway officials indicate these officials want well-informed public guidance so that the business point of view is properly represented. There may be situations where several alternate routes would be equally desirable to move traffic, but only one best for business and other economic factors. These cases particularly should receive guidance from the business community.

Another objective should be to insure the wise expenditure of tax dollars for highway and street purposes. Today's highway gold rush unquestionably will have a greater impact upon the national welfare and economy than its predecessor of 'forty-niner days. Businessmen have a responsibility to see that this rush is not headlong with wasteful expenditures of public tax dollars. In the hurry to get these needed roads built as quickly as possible, highway routes may be located without first having been given proper study.

A further objective should be to insure that a co-ordinated urban transportation plan is included in this highway program that will build better cities and improve business. The building of highways alone is not enough. Highways are of value to the extent that they not only provide communication between cities but also that they are co-ordinated into an overall urban transportation plan that takes into account all forms of transportation and parking.

A final and important objective should aggressively promote public support for needed street and urban transportation improvements. A good example is found in the program of the Columbus Chamber of Commerce, in Ohio. There, the mayor of the city solicited the chamber to support a long list of public improvements, including street and highway construction, and asked the chamber to get endorsement from other civic bodies. Invited to participate in

this work were more than one hundred organized groups including labor, women, civic, business, trade and neighborhood. This metropolitan committee has been their community medium to promote public improvements.

Implementing A Road Program

How to implement these objectives is the next step.

1. There should be an aggressive highway or transportation committee. The survey showed that some of these committees get rather sizeable. In San Antonio, Texas, for instance, the chamber of commerce has ninety key members on its seven-part committee. Winston-Salem also has a large street and traffic committee divided into four parts, each comprising from six to eleven members.

2. Committee activity should be co-ordinated with other civic groups and organizations working toward the same objectives, and these groups should counsel with road-building officials. The California State Chamber of Commerce has done an outstanding job along these lines. It attempts to co-ordinate all recommendations of city and county officials and other leaders throughout the state into a single organized presentation before the State Highway Commission, and also sets a priority on essential projects. The Salt Lake City Chamber of Commerce of Utah organized the Utah Advisory Council, a powerful organization with which the road commission consults regularly in developing its road program.

3. Chambers should sponsor highway conferences, hold meetings with public officials and other civic groups, attend hearings, conduct tours of road and transportation improvements and have special luncheons to discuss highway matters. A meeting planned by the Columbia Chamber of Commerce, South Carolina, included its street and highway committee, the mayor, city council, city planning board, garden clubs, interested individuals who could mold community opinion, the highway commissioner, and representatives from the Bureau of Public Roads.

4. Promote traffic surveys and economic studies. With thousands of miles of streets and highways having to be improved and relocated, sound economic studies are vital. This is one point that a local chamber should insist upon where its community is affected.

5. Prepare bulletins, pamphlets, reports, and use radio and television programs. The Indiana State Chamber of Commerce published a number of well-written and illustrated booklets covering various phases of the highway program. A few are: "Is Limited Access An Answer To This Hoosier Headline?"; "Financing Indiana Roads and Streets"; "A Digest of the Federal-Aid Highway Act of 1956."

An article in the *Burkes Booster* discussed a proposed by-pass under big headlines, "Chamber Urges By-pass Support." Local chambers are more and more getting behind by-pass programs when they study all the facts involved and find that in most cases by-passes are a boon to both individual business and the entire community.

The Los Angeles Chamber of Commerce, California, has conducted a weekly radio program devoted primarily to explaining the state freeway development in the Los Angeles metropolitan area. This has a good effect in keeping the public informed so it understands the program.

6. Work with legislative bodies in the interest of a highway program. One of the greatest needs today is appropriate modernization of state laws to administer and finance the road program. The business community can play an important part in this task.

7. Help highway departments to obtain rights-of-way. The Oklahoma City chamber of commerce purchases well in advance of need rights-of-way for state routes within the city. In Hot Springs National Park, Arkansas, the chamber successfully reconciled the jurisdictional controversy in regard to right-of-way purchase and assumed a portion of the actual cost.

Public officials need and seek guidance of the business community, and support in their efforts to get this great highway program under way. Every businessman and the public generally must work for progress and oppose delays in this program designed to hasten the day when America will have a safer, more efficient network of superhighways. We have thirteen short years to complete this project, and all the resources of the nation will be required to perform the task.

Designing Roads for High Capacity

RALPH L. FISHER

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MANY years ago it was said that all of the easy routes had been built. Each year it becomes increasingly difficult to find a feasible location for a new highway or the elbow room to improve an existing road.

During the period of getting us out of the mud, the emphasis was almost entirely on mileage. Later, as traffic volumes and speeds increased, it was comparatively simple to find open areas for new routes that could be built to higher standards of alignment and grades. The old road could be forgotten as nearly all traffic moved over to the new route.

In more recent years, further increases in traffic again overtaxed many sections of our routes. This time few, if any, open areas were available for a new road. To avoid a large loss in tax-paying property it was necessary, whenever possible, to locate the highway through swamps, along old canal beds, or adjoining the sides of steep hills. The result was relatively low cost of right-of-way but greatly increased construction costs.

With the rapid increase in land values, developers (particularly those interested in large acreage or industrial tracts) are using these normally undesirable tracts. If the present trend continues, all new routes near urban areas soon will, of necessity, have to cut through developed areas. This will greatly increase the average cost per mile and further reduce the number of miles of new roads that can be constructed each year with current funds.

Many areas have thus about reached the end of solving highway problems by moving over to a new route. The emphasis is now on

designing facilities balanced for capacity that can be retained under future conditions, including changes in traffic patterns and development of the area.

At low volumes, nearly all routes seem adequate. It is when volumes increase towards capacity that defects and weaknesses in design become apparent. Another reason for modern emphasis on capacity is that new routes usually provide only temporary relief to the nearby older routes. Unlike the earlier by-pass, most traffic does not move over to the new route.

Reasons for this are varied. However, in general, long-distance travel accounts for only a small percentage of total traffic volume. Short-distance, local traffic accounts for most of it. Usually only half the total traffic has destinations beyond cities with less than 5,000 population. This percentage drops to 7 percent for cities of more than 500,000 population.

As an example, let us suppose that the opening of a new route reduces traffic on the old route by 25 percent. If the annual average increase in traffic in the area is 5 percent per year, the relief would only last five years. This means that the older-route problems are back again and, with yearly increases in traffic, become more critical each year. In some cases, new construction thus only briefly defers needed improvements to an older route.

An increasingly common practice is to spend considerable sums of money to increase the capacity or safety of an older route.

Problems of Design

Design problems on main routes fall into two main categories: (a) improving an existing route and (b) routes on new alignment.

A. Increasing Capacity of an Existing Route

1. Two-lane road.

In urban areas this change may consist of minor channelization with or without traffic-signal control at intersections; paving additional lanes through the intersection, particularly at signalized intersections; prohibition of some turning movements or parking restrictions.

In rural areas, reduction in capacity caused by an occasional sharp curve or steep grade can sometimes be corrected at reasonable cost. Capacity on longer grades can be maintained with "hill climbing" or "creeper lanes."

2. *Dualization of two- or three-lane roads.*

The usual practice is to acquire only sufficient right-of-way (on one side of the existing route) for construction of additional lanes adjacent to the existing road. This method leaves the route without protection against almost certain serious loss in capacity because of roadside development.

Widening of this kind generally eliminates the existing frontage on one side. In most cases additional depth of right-of-way can be acquired at reasonable cost and can be used for stage construction to provide varying degrees of protection to highway capacity. The first stage can be the usual dualization described above. At stage two, another roadway could be constructed adjacent to the first stage. The original two-lane road could then become a service road.

If the right-of-way for the dualization had been acquired on the basis of limited access (or with adequate control of access), stage two should tend to preserve the capacity indefinitely. If it was not feasible to acquire the access rights, consideration could be given to acquiring sufficient depth (on the widened side) for a future service road as a third stage.

With service roads on both sides, the route would be protected from ribbon development. This method would be particularly effective for by-pass routes.

Control of access and preservation of capacity have been concentrated on our more glamorous freeways and parkways, but little consideration has been given to dualization or other improvements of short sections of our work-horse routes.

3. *Improvements to an existing dualized route.*

Many dualized routes have openings in the center island at local streets and driveways. With increased traffic volumes and speeds, these openings have become the source of accidents. Complaints of hazards and delays are received not only from local users but also from through-traffic operators.

In the past some relief was afforded by providing storage space in the center island for left-turning movements. As volumes on the main roadway increased, completion of the left turn against opposing traffic was more difficult. Another disadvantage of this design was lack of sufficient turning radius for U turns, particularly for commercial vehicles.

"Jug handles" overcame these disadvantages. (See Figure 1). All turning traffic leaves the main roadway and completes the turn from the side road. Traffic signals are generally used with this type of turning facility. This design may also be used for stage construction. A jug handle is installed initially but sufficient right-of-way is acquired for a future interchange.

When island openings are closed (or not provided for in the initial design) facilities must be constructed at intervals for left and U turns. These facilities may consist of special channelization, such as jug handles with traffic signals, or grade separations with necessary ramps.

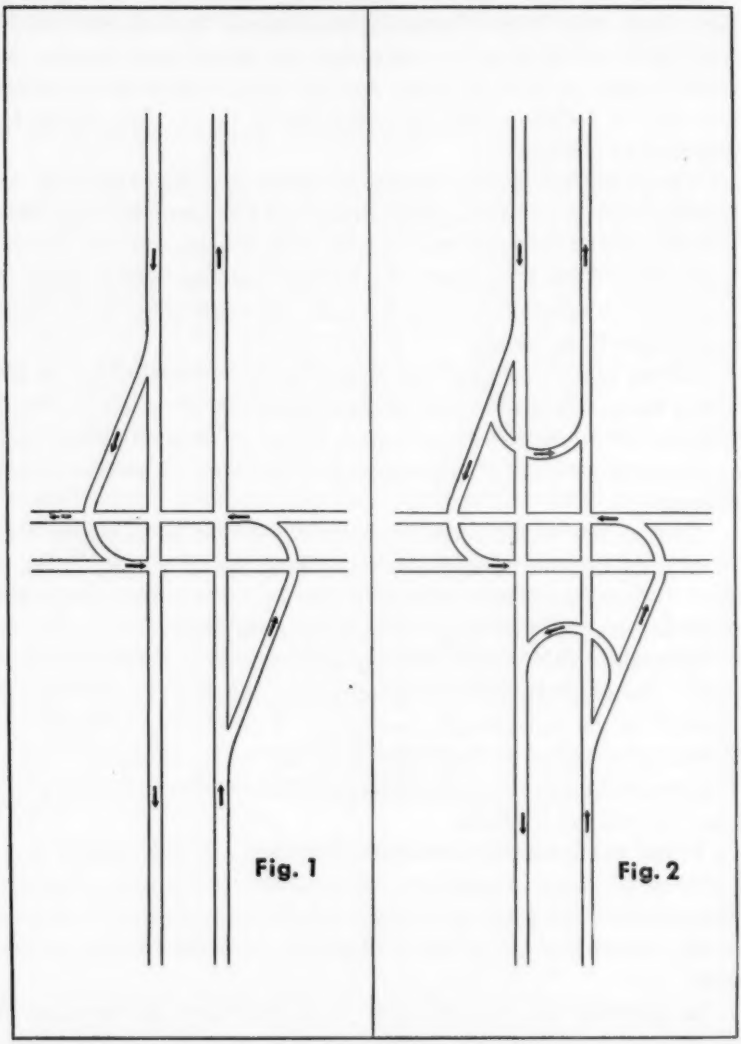
During the design stage, information should be obtained concerning the number of vehicles that will use the turning facilities. If the U-turning movement is large, it may be necessary to provide for it just in advance of the jug handle as shown in Figure 2.

If possible, the jug handles should be spaced at a distance equal to the product of the desired operating speed (in feet per second) and one-half of the cycle-length in seconds. This spacing will provide perfect progression in both directions for traffic-signal operation. This method generally gives distances of two to three thousand feet between turning facilities.

When grade separations are used, bridges can generally be seen for some distance in advance and the public will accept greater distances between turning facilities. However, even then motorists would probably object if the bridges are more than a mile or two apart.

In planning new interchanges, consideration should be given to providing for turning movements even though the median openings are not to be closed initially. Some types of interchanges do not lend themselves to U-turn movements.

It is sometimes necessary, when openings are closed on an existing route, to revise the ramps at an existing interchange so that re-



versal of direction can be accomplished. In urban areas where grade separations are rather frequent, it may not be necessary to provide for U-turns at every interchange.

4. Improving an existing interchange.

Many of the older interchanges did not provide for all turning movements because there was little or no traffic demand for them at the time of construction. Since the area adjacent to these interchanges generally has experienced extensive roadside development, revision of an existing interchange frequently is expensive.

The limited data published on interchange design have been primarily for new interchanges and the designer has to draw on his own ingenuity to patch up weak or outmoded portions of older interchanges.

Ironically, this patching makes further improvements more difficult. It also increases the amount invested in the interchange and may delay indefinitely scrapping the entire facility and constructing a modern interchange.

Figure 3 shows how additional turning movements will be provided for at the intersection of two older routes in New Jersey.

In the original design, provision was not made for moving traffic between points one and two. This movement was originally quite small and could be made in a roundabout manner over local streets. As traffic volumes increased, it became more important (particularly for trucks) and the use of local streets proved objectionable.

Because one of the routes was on a 6 percent grade, conventional ramps for movement between points one and two would have resulted in excessive grades. Constructing ramps A and B at a nearby local road resulted in flat grades and eliminated left turns. The return movement was provided for by the construction of ramps at C.

Closely spaced interchanges may seriously reduce capacity, resulting from cross weaving at entrance and exit ramps. Figure 4 shows a method of eliminating this cross weave by construction of an additional bridge.

Traffic entering the highway at point C had to cross weave in a short distance with traffic desiring to exit at point D. A large increase in volume made this cross weave troublesome. The original ramps were removed and ramps E and F constructed.

These alterations can do much to improve the safety or capacity of an older route. Such improvements are made without fanfare or publicity and do not receive the attention they deserve. Other bene-

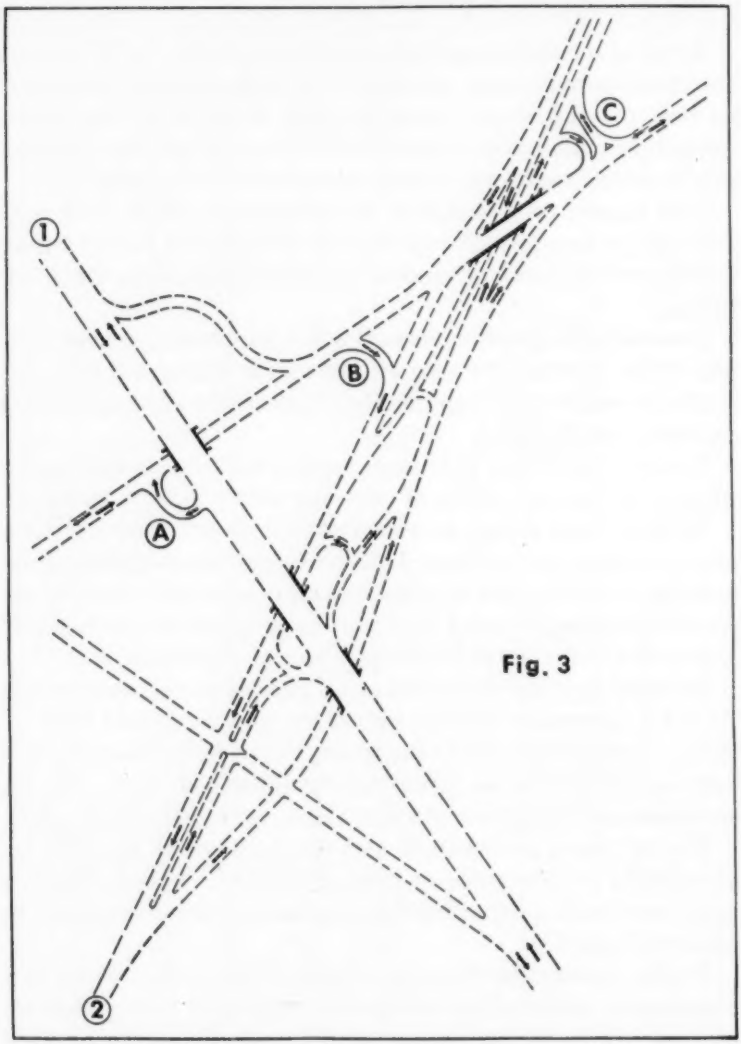


Fig. 3

fical changes include creeper lanes, widening narrow pavements, improving corner radii, superelevating or flattening sharp curves, modern signs and pavement markings.

B. Routes on New Alignment

It has been stated that modern freeways consist of interchanges connected with the proper number of lanes. In any event, interchanges may largely determine the location of the route. An area that offers an economical route is useless if it results in cramped, inadequate, improperly located interchanges at excessive cost.

The designer should always keep in mind that traffic can enter and leave the facility only at interchanges. A delicate balance must be maintained in their spacing and location. As pointed out, closely spaced interchanges may seriously reduce the capacity of the route. If improperly located, or spaced at rather infrequent intervals, they may not provide proper service to the area.

To prevent objectionable conflicts between entering and leaving traffic streams, interchanges should be at least a mile apart. Greater distances are highly desirable and two to three miles should be considered as desirable minimums. This spacing of interchanges will allow the posting of signs in advance and give exit traffic the necessary time for moving to the proper lane. A sign a mile in advance is none too much if a driver has to cross two or more lanes before reaching the exit.

At major interchanges, the cloverleaf type of design should be avoided for important traffic movements; it has the serious defect of (1) a cross weave taking place in a short distance and (2) a high volume of traffic entering before a high volume leaves. For such cases it is necessary to have the exit ramp in advance of the entrance ramp, as shown in Figure 4.

One of the most disconcerting maneuvers on a high-volume route is the need for a driver to apply his brakes suddenly because he has just discovered that the driver in front has braked for a turnout.

Such maneuvers are not conducive to capacity or safety. An adequate deceleration lane allows the driver to leave the through-traffic stream and make his exit with little if any braking.

Acceleration lanes should be designed to (a) induce traffic to enter the main roadway at a flat angle and (b) be of sufficient length to provide the necessary merging area. About 1,200 feet is generally necessary to provide proper merging.

Entrance and exit lanes designed on these principles have been in operation for many years and have been almost accident free.

Multi-Lane Facilities

A substantial mileage of four- and six-lane highways has been built and for their design it is possible to draw on experience gained from years of operation. On the other hand, only a relatively few short sections of multi-lane facilities have been constructed. Data for design of routes of eight or more lanes are lacking and the design of such facilities is a controversial subject.

A tendency to carry over the same design principles for multi-lane roads as were used for older four-lane routes, the writer believes is highly questionable. An entirely new phase of highway design may be at hand.

Some are of the opinion that eight lanes are the maximum that should be used. They believe that if eight lanes will not handle the traffic demand, then another route should be constructed. The author disagrees with this thinking for the following reasons:

a. It is becoming extremely difficult to find public support for new routes in urban areas. Increasingly large numbers of local officials and citizens object to the taking of properties for a new road in their municipality and will support a highway program only if the route is relocated to a nearby community.

Under these conditions, a highway administrator would encounter considerable local resistance even to the idea of building a new road through an area and then coming back in ten or fifteen years to cut another major route through the community.

b. The need for larger capacity (and therefore more lanes) is greater than is generally recognized.

A few years ago 40,000 vehicles-a-day-roads were almost unknown. Today they are fairly commonplace and several sections of the country have routes in the 100,000-a-day category. For these routes, a 5 percent increase in traffic volumes a year means that in two years, capacity must be found for 10,000 additional vehicles a day.

c. When a future increase in traffic volumes creates difficulty, there is every probability that because of insufficient funds, resist-

ance to the erection of another "Chinese wall" or other reasons, an easy solution to the problem will be sought. The easy way is rather obvious—find the space for additional lanes by narrowing the center island or doing away with the shoulders.

An initial four-lane route could thus become six or eight lanes and an initial six-lane route, an eight- or ten-lane facility. If the possibility of such widening is not considered in designing the original route, results could be unfortunate.

It is believed that multi-lane facilities of the dual-dual type can be constructed that have none of the serious disadvantages of four or more lanes in one direction. There is almost universal agreement that with four or more lanes in one direction, full-width shoulders should be provided on both sides. To convert a facility of this type to a dual-dual type requires merely the addition of narrow side islands. The only remaining consideration is the design of interchanges.

The principal complaints from the public concerning four or more undivided lanes in one direction have been (1) a dislike to drive in the middle lanes with trucks on the right and faster moving vehicles on the left, and (2) the necessity of crossing two or more lanes of traffic at exits. During high volumes, this crossing can become an impossibility.

Figure 5 shows a dual-dual facility with entrances and exits from both roadways. At less important interchanges, connections at the outer roadways only would probably be sufficient.

Figure 6 shows another method of providing connections from both roadways. If the side island were omitted and the dual-dual type not used, the only saving would be the bridge and ramp over the local roadway, two of which would be needed for a complete interchange.

Many interstate routes in the East carry from 20 to 25 percent commercial traffic. For a 50,000-AADT volume—6,000 vehicles for the design hour—1,200 to 1,500 vehicles an hour would consist of trucks. With the tendency of these vehicles to keep in the right lanes, vehicles in the left lanes sometimes have to break through a solid line of trucks for conventional exits on the right.

The design in Figure 6 eliminates the necessity of crossing several lanes of traffic. Instead of concentrating exit traffic on one ramp, three exits provide high capacity and eliminate cross weaving on the

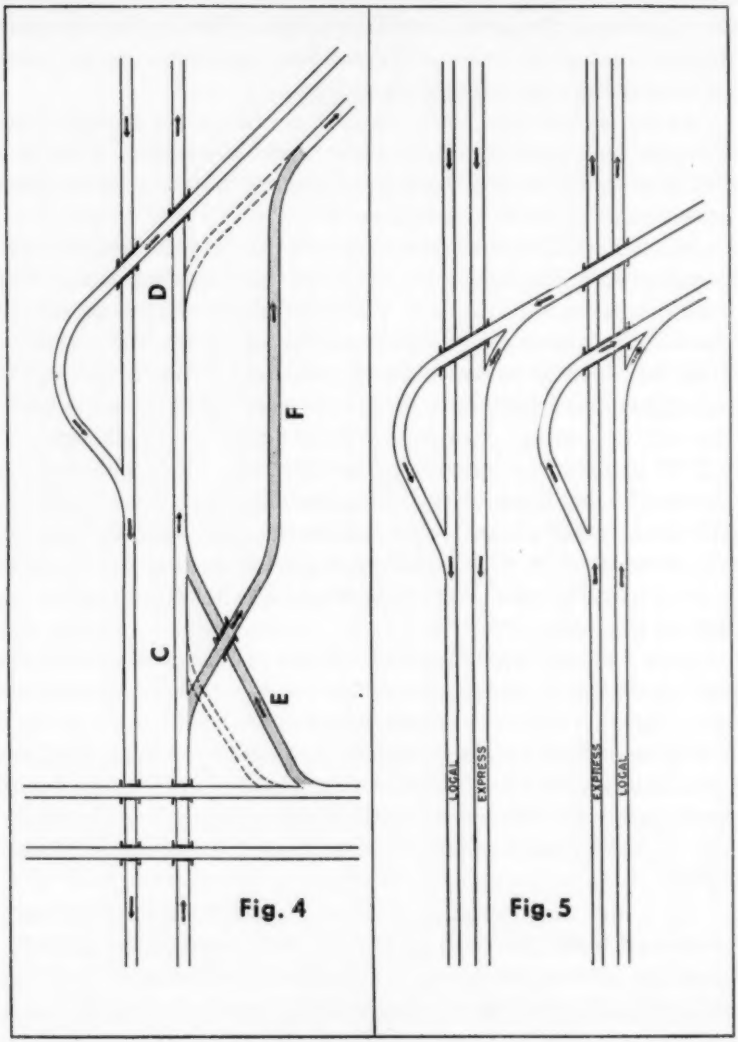


Fig. 4 Fig. 5

ramp. For lower volumes, one of the ramps from the local roadway could be omitted.

Figure 7 shows another type of interchange with ramps from

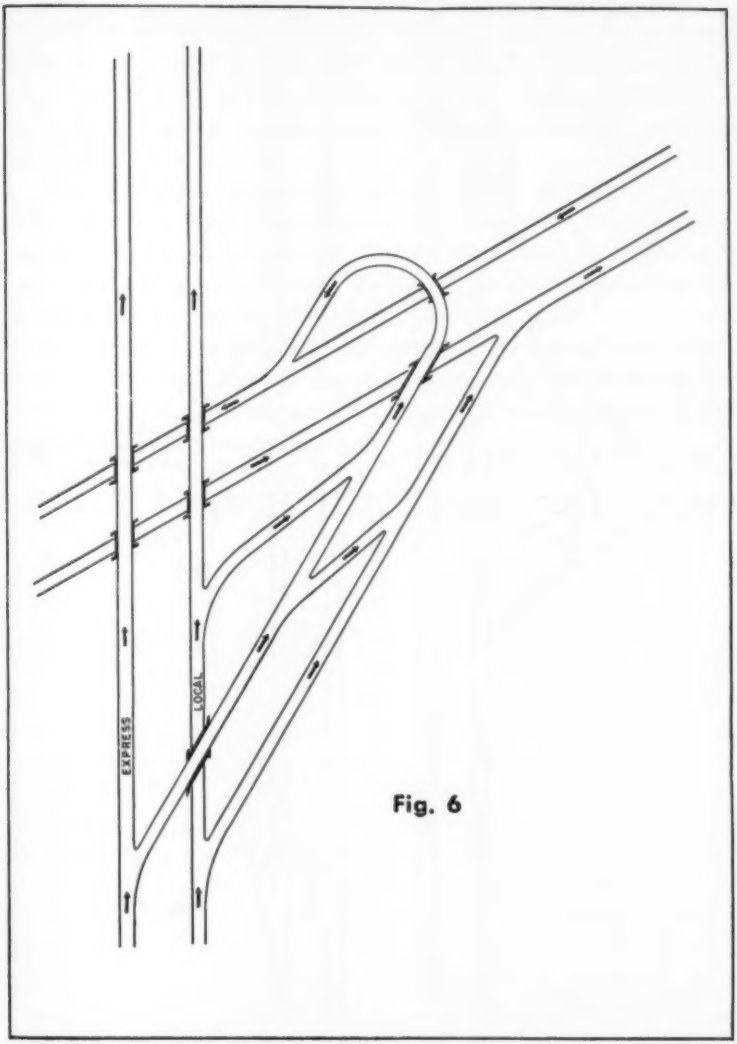


Fig. 6

both roadways. The inner loop would be used for the ramp with the lowest traffic volume.

For years motorists have requested separate routes for trucks.

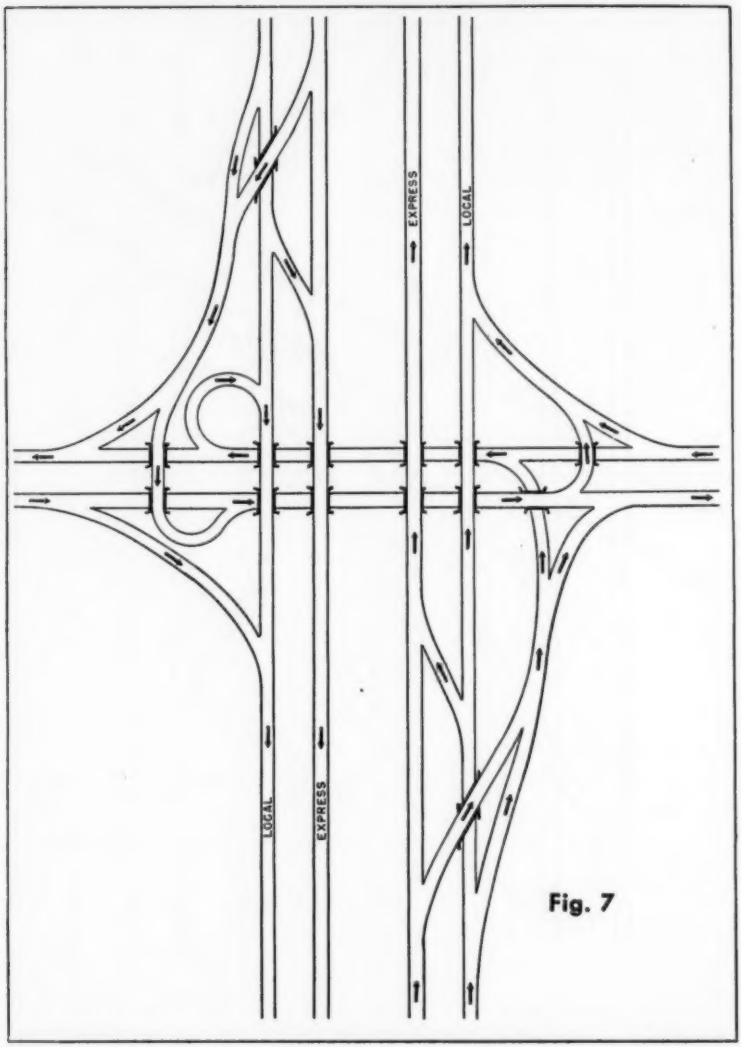


Fig. 7

Many commercial vehicles cannot maintain speed on grades as low as one and a half percent. This results in greatly reduced capacity. Highways are designed for passenger-car braking distances, but many trucks require twice these distances.

With the dual-dual facility, commercial vehicles can be restricted to outer roadways, and the inner roadways reserved for passenger vehicles. This practice has been successful for some time on the north-bound lanes of U.S. 1 dual-dual in New Jersey, and is one of the major advantages of the dual-dual type that has been generally overlooked.

The dual-dual facility provides flexibility of construction. In most cases, only two lanes of outer roadways would be constructed initially. As volumes increased, another lane could be added to the outer roadway or two lanes of the inner roadway constructed. The ultimate design could be three lanes in each roadway.

It is believed it would be extremely short-sighted not to make the relatively minor adjustments to permit future dual-dual type of construction. This plan would afford low-cost insurance against future unknown quantities.

The Executive-Management Aspects of Traffic Engineering

A. F. MALO

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THE rise of the traffic engineer to his present position of importance has made him an executive. With his management rights and privileges, he has additional responsibilities and obligations. The sound direction of the traffic engineering agency is one.

In early days, as advisor or consultant, the traffic engineer was not concerned with budgets, personnel selection and placement, the solicitation and maintenance of public support, and the other activities to which the head of any governmental agency must devote considerable attention. Now he finds that the recognition of traffic engineering as a major activity means that the traffic engineer has executive and administrative responsibilities. While not technically a part of traffic engineering, his added duties do affect the traffic control program. And with the growth of the traffic problem and the increased reliance upon trained specialists, the traffic engineer moving toward the top position in his organization will need to demonstrate executive capacity. Because of this fact, it would be well to review the management functions of the traffic engineer's position and attempt to point out those particular management activities with which he must be familiar.

Prior to any discussion or consideration of the management aspect of traffic engineering, the legal status of the traffic engineering agency should be carefully reviewed. Sound management becomes ineffective when the duties, responsibilities, and authority of the traffic engineering agency are not clearly spelled out in the charter or constitution.

In many areas, the traffic engineer is responsible for providing the safe and expeditious movement of traffic, and yet does not have sufficient legal authority to attain this objective. While he may be charged with the responsibility of achieving the most efficient use possible of the street system within his area, he may find he has been assigned no legal interest in the planning, design, or construction of these facilities.

In some communities the duties, responsibilities, and authority of the planning board, the enforcement agency, the public works department, the public lighting department, and other agencies overlap or conflict with—in some cases negate—those of the traffic engineering agency. Under that complex legal arrangement, even a minor street widening might require action by several agencies, such as the executive and legislative branches of the governmental unit involved plus the agencies already mentioned. Such an arrangement would seriously minimize the advantages of good management.

Legal Status

The first step, therefore, in reviewing the legal status of the traffic engineer and his agency is to determine whether all functions relating to the planning or control of traffic facilities are placed under his jurisdiction. Following this review, those functions performed by other departments, properly the work of the traffic engineer, should be reassigned to his agency. In addition, the working relationships between the traffic engineering organization and other governmental agencies should be clearly defined.

While the planning body may have a charter or constitutional responsibility for the development of the master plan, the planning of the traffic network should be the direct responsibility of the traffic engineer subject only to review by the planning officials. While the actual work of street and highway construction and resurfacing might be assigned legally to the public works or highway department, the establishment of standards, priorities, and selection of routes should be assigned to the traffic engineer.

It is only when the traffic engineering agency rests upon a sound and firm legal foundation that it can operate effectively. Certainly the principles of good management are essential to success, but the

first and primary requisite is a clear definition of duties and responsibilities accompanied by sufficient legal authority to permit the traffic engineer to proceed in an orderly and businesslike manner.

Organizing His Operation

Having established the legal status of his agency, the traffic engineer organizes his operation so he can carry out his assigned responsibilities. Here he will apply sound personnel management and administration. Keeping in mind the major duties of his organization, he will organize his agency around the principal duties assigned to it. In setting up the organizational structure to cover each principal duty, he will supply the civil service department or whatever other personnel procurement agency is involved with a list of qualifications for the personnel who will staff the agency.

Recognizing the degree of training and experience which such personnel must possess, he will be in a position to counsel with the recruitment agency on the establishment of salary schedules and promotional possibilities. He will conduct surveys which will provide him with first-hand information on pay schedules maintained by other governmental and private organizations for comparable work. In analyzing the duties for each position in the organizational structure, he will be able to point out to recruitment and procurement personnel the special qualifications required of applicants for assignments involving contact with individual citizens, civic groups, business and industrial organizations.

Staff and Line Control

In studying the subject of internal organization and personnel placement, the traffic engineer will consider the problem of staff and line control. He must realize that the activities of a governmental agency are closely scrutinized by the public since such activities are quite properly the subject of public interest. Furthermore, as head of such an agency he must answer directly to the public. He is accountable for every act of commission or omission by every member of his organization. He alone must explain and defend every decision and action of his agency despite the fact that because

of the urgency of the problems at hand, he will not be able to study each individual problem personally.

He will have insufficient time to review all the factors that lead to a particular decision. He should develop a staff of specialists in whom he can place complete confidence and to whom he must delegate considerable responsibility and authority within their specialities. In the delegation of authority and responsibility to his major assistants he must make certain that the chain of command is defined, and that supervisory responsibilities are fully understood so that a review procedure is established to insure that every phase of a problem is considered before a final decision is reached. This means in essence that the traffic engineer must devote his time and energy to major problems of policy and procedure and must expect his top staff to work out details and solutions within this broad framework.

Communication

In line with the proved principles of personnel management, the traffic engineer will give special consideration to communication between various sections and divisions of the agency through definite and established channels, such as regularly scheduled staff meetings, periodic reports or through other means.

Regularly scheduled staff meetings aid in solving problems through the reporting of progress and the exchange of information between members of the staff. Such a procedure also stimulates greater interest in the overall problem by the entire staff. Occasionally expanded staff meetings should be held to include personnel in subordinate positions who ordinarily would not be participants in such discussions.

That procedure will help to establish better working relationships and will give younger employees an opportunity to obtain first-hand information on the overall operation of the agency.

Developing Young Employees

The professional advancement and development of younger employees in subordinate positions should be of special interest to the traffic engineer. He should employ every opportunity to advance

the capabilities of younger personnel. This can be done through the regular practice of employee counseling by trained and experienced personnel, the incorporation of refresher training, and in-service instruction and the policy of position rotation so that employees are afforded the opportunity to broaden their backgrounds.

In developing the organizational structure special attention must be given to the matter of research. Most traffic engineers recognize the fact that remedial action taken to solve today's problem is not alone sufficient.

If progress is to be made, we must anticipate the problems of the future and take the necessary preventative action now so that new problems will not plague us in the future. These facts must be taken into account when the organizational structure is established so that provision is made for this activity and so that personnel may be recruited for it.

Research

Fact-finding activities, such as the traffic counts, speed and delay studies, the investigation of accidents, and other traffic engineering assignments provide data that should be used in research. Time should be provided, and employees encouraged, to apply data to simple research projects within their phase of the work.

Insistence should be made on 'before and after' studies so that the value of new regulations and methods might be established. As a matter of policy, the traffic engineering agency should co-operate with all national committees and groups conducting research by furnishing requested data, the results of which will eventually be available for use by all traffic engineering agencies and thus will pay special dividends to those who co-operate in such programs.

The ideal situation calls for the establishment of a special research group within the traffic engineering agency with the sole responsibility of conducting investigation, study, and experimentation designed to provide new regulations to permit traffic to flow with greater ease and safety. While this is the ideal toward which all traffic engineering agencies should strive, it should be remembered that any move in this direction is a step along the road of progress.

Probably the most important and disturbing problem is that of finance. He will be required to prepare budgets, to set up and maintain cost accounting records, to employ strict inventory controls and to conduct continuous studies designed to reduce operating costs and increase the efficiency of his operation. In short, he will be constantly under pressure to provide more and better service for less money.

Finance

To accomplish all of this, the traffic engineer should be familiar with the fiscal policies of the unit of government that hired him. He must know in detail the tax structure which provides the funds for his operation. He must be well acquainted with the provisions of federal, state, county, and local laws that spell out the manner in which gas, weight, and vehicle taxes must be distributed.

Trained Personnel

Because of the degree of specialized training required in connection with the preparation of the operating budget, the maintenance of cost accounting records, etc., the traffic engineer will doubtless want to obtain the services of trained personnel to assist him in this phase of his work. Most progressive traffic engineering agencies have made provision for accountants and cost analysts in their organizations. The retention of such specialists is not alone enough.

The technical personnel in engineering positions should understand the financial problem to establish priorities and break large programs down into various stages of development so that consecutive units of improvement can be scheduled. This calls for sound, long-range, and thorough planning to insure that funds expended secure the greatest return per dollar of expenditure.

It means that the traffic engineer, in accordance with modern business practice, should insist that staff personnel, both engineers and accountants, keep abreast of the latest technological advances in equipment and improvements in procedures so that every opportunity to reduce costs is fully exploited.

While the ideal situation calls for the concentration of all activities dealing with the traffic problem in the traffic engineering organization, it should be recognized that local conditions, traditions, personalities and other factors will make it impossible in some instances to fully achieve this objective. There will be, therefore, in some cases activities such as street resurfacing, highway and street construction, traffic signal installation and maintenance, and pavement marking carried out by agencies apart from and independent of the traffic engineer. Where this situation occurs, sound management dictates that sufficient authority be given the traffic engineer by the charter or constitution to enable him to supervise these activities.

Control of the Budget

This authority should give him the power of review and final approval on all such activity. One method of providing the traffic engineer with this authority would be to give him control over that portion of the budget to be used by any other agency in traffic work.

This control could be maintained by giving the traffic engineer the authority to decide the scope of any construction project or installation program to be performed by any other agency and by requiring his approval for any expenditure made against the budget allocated for these activities. Regardless of the method employed, it is essential to the success of the overall program that this authority be vested in the traffic engineer.

Success Includes Enforcement

The success achieved in any traffic engineering program is dependent in large measure on the effectiveness of the traffic law enforcement program. Parking regulations and prohibitions, turn restrictions, and speed limits designed by the traffic engineering agency to provide for safety and ease of movement have little meaning until they are made the subject of a vigorous, continuous and impartial enforcement program.

Although the traffic engineering program is thus dependent upon the effectiveness of the enforcement program, the two are clear and distinct areas of activity. While the traffic engineer should not

inject himself into the enforcement picture and while it is unwise for the police officer to assume traffic engineering functions, there is a very urgent need for close co-operation between the engineering and enforcement agencies.

Management practices would call for the establishment of close liaison in such a situation. The effectiveness of both programs depends upon continuous communication and co-operation between these two groups.

Co-operation

An example of such close and continuous co-operation is the method employed by one large city that has established, by interdepartmental consent, a traffic co-ordinating committee whose membership consists of the traffic engineer, the top command of the police department, a representative of the traffic courts, and the local industry-supported traffic safety association. This committee has been extremely successful in carrying out community-wide safety programs and in cementing the relationships between the police, the courts and the traffic engineer.

The committee may not be required or may not be the answer in other communities. Personalities involved or local departmental policies may dictate other methods of accomplishing the co-operation desired. Whatever method is employed, the traffic engineer should take the initiative in creating a favorable atmosphere for this type of co-operative activity.

Management of business and industry recognizes that public support is essential to success. Public support is generally secured through the operation of a sound public relations program. As a matter of fact, progressive business and industrial leaders today recognize public relations as a management function. They are aware of the fact that public support is obtained through information, education and action programs, which first of all gain public understanding and thereby secure public acceptance and support. Important as it is to the success of business and industrial activities, public support is even more important to the success of traffic engineering. A public that does not understand and thus will not accept the recommendations and programs of the traffic engineer will render any program totally ineffective.

It is incumbent, therefore, upon the traffic engineer to make use of the management tool known as public relations. In some traffic engineering agencies, recognition of this fact has led to the retention of a public relations specialist. This, alone, is not sufficient to obtain the desired objective. The public relations specialist can help develop good relationships with the mass media of the area, with civic groups, service clubs, and business and industrial organizations.

He can counsel with departmental personnel on the proper handling of public contacts, and he can help reduce some of the misunderstanding which arises between the traffic engineer and the public he seeks to serve. The ultimate success of any public relations program, however, rests upon the acceptance by the traffic engineer of the public relations attitude—a sincere desire to understand and to assist the public and his insistence that all personnel of his organization conduct themselves in accordance with this idea.

Big Business

Traffic engineering has become big business. While the individual traffic engineer may not realize this fact when he is considering the installation of a stop sign or a yield sign or even when he works on the plans for an expressway, he is in fact involved in one of the biggest and most important undertakings in the United States. The streets and highways of America have become in many instances extensions of the production lines of our factories.

The traffic arteries of this country have become our main supply routes. They are indeed the life lines upon which the commerce, industry, and defense of this nation depend. To the traffic engineer falls the grave responsibility of keeping these life lines open and operative. In addition, he must make certain that the vast new network of limited access highways authorized recently by Congress includes those design features which will make it safe and efficient.

The magnitude of the task which confronts him should make the traffic engineer realize that he is not only engaged in big business, but that to be successful he must employ those tools which bring about success in modern business and industry. In short, he

must be familiar with the principles and practices of modern business management and must insist upon their application in the daily operation of the traffic engineering agency.

Improving Management Know-How

At this point, the traffic engineer might well ask by what means he could acquire additional knowledge and training in the principles and practices of modern business. There are several courses of action open to him.

He should analyze his own experience and training to determine whether or not additional training in public administration and business management is necessary. He should give serious consideration to enrolling in special courses in these fields, the opportunities afforded him to participate in management seminars and clinics and the benefits to be derived from private reading and study of these subjects.

He should encourage institutions currently conducting courses in traffic engineering to revamp their programs to include classroom training and discussion in these areas. This additional training will permit tomorrow's traffic engineers to arrive on the scene better equipped for the job that will face them. Moreover, their introduction to this aspect of the traffic engineering profession early in their training will no doubt stimulate a continuing interest after they have been graduated.

Earned Prestige

The success of the traffic engineer in handling the technical aspects of his job has earned for him increased prestige and greater standing in the community. The complete success of his program, however, will be achieved only when he has become as proficient in the executive and administrative functions of his position. If he wishes to achieve greater personal satisfaction from a job well done and if he desires to make an even greater contribution to the safety and welfare of his community, he will seek to become acquainted with these principles and will incorporate them into the operation of his agency.

The Planning for Traffic Operations For the Lincoln Tunnel

WARREN S. QUIMBY

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AFTER World War II, vehicular traffic increased at an unprecedented rate. While a return to prewar level was expected after the wartime low, few officials foresaw the surge encountered.

Within the metropolitan New York area, the impact was felt on primary connecting links across the Hudson River between densely populated areas of New Jersey and Manhattan—the George Washington Bridge, and the Lincoln and Holland tunnels. Between 1930 and 1941, trans-Hudson vehicular traffic increased from 25.8 to 42 million vehicles a year—an average annual increase of 1.5 million vehicles. In 1946, trans-Hudson traffic totaled 43.5 million.

Thereafter, this figure almost doubled: last year, 79.8 million vehicles crossed the Hudson River—an average yearly increase since 1946 of more than 3.5 million. Translated into terms of rush-hour experience, the rapid mushrooming of traffic could be daily witnessed in increasingly congested conditions on plazas and approaches, particularly at the Lincoln and Holland tunnels.

The Port of New York Authority, responsible to the states of New York and New Jersey for developing trans-Hudson vehicular facilities, recognized as early as 1949 the need to relieve these Hudson River facilities—only four years after the opening of the second tube of the Lincoln Tunnel and before the New Jersey Turnpike advanced beyond the talking stage.

In 1949, an extensive origin and destination survey, to determine when, where, and to what extent additional vehicular crossings were required, indicated that a substantial portion of trans-

Hudson vehicular traffic would be benefited by crossings to permit this through-traffic to bypass Manhattan north of the George Washington Bridge and south of the Battery. The survey also indicated that approximately 50 percent of the traffic, with origin or destination in Manhattan, had to be accommodated by additional capacity, particularly in the mid-Manhattan area.

Therefore, the Port Authority proceeded with plans for adding a third tube to the Lincoln Tunnel as the most logical means for gaining the additional capacity needed for mid-Manhattan. A third tube added to the two existing tubes would not only provide urgently needed relief to that facility but also to the Holland Tunnel and the George Washington Bridge.

Traffic Growth at the Lincoln Tunnel

The annual volume of traffic of all types through the Lincoln Tunnel in 1947 was approximately 10,600,000. In 1956, this figure increased to about 21,700,000 vehicles—more than double the 1947 volume.

Passenger cars represented approximately 77 percent of this total volume; trucks, 11.5 percent; buses, 9.5 percent. Although passenger car volumes increased at the greatest rate after 1947, all classes of vehicles show substantial increase, and no single element can be charged as wholly responsible for peak-hour congestion.

Traffic characteristics inherent in the Lincoln Tunnel are significant in analyzing the problem. The attractiveness of New Jersey highway connections with the tunnel, particularly the direct interchange with the New Jersey Turnpike, has contributed to the increased use of this facility by vehicles having origin or destination in midtown Manhattan.

The estimated practical capacity of the present two tubes of the Lincoln Tunnel is 22,000,000 vehicles a year. This limit was just about reached in 1956. Only off-peak periods—early morning or late evening hours—afford a margin of capacity.

Needless to say, during rush-hour periods serious backups have frequently occurred on Manhattan streets leading to the tunnel and also on the helix approach to the tunnel in New Jersey.

By increasing the capacity of the Lincoln Tunnel to three tubes, a substantial portion of the present congestion could be removed. However, traffic figures indicated that serious overloading of east-west exit streets in the vicinity of the Manhattan plaza would occur during rush hours if two tubes, or four lanes, of traffic instead of one tube, or two lanes of traffic, were permitted to exit. The effect of this would be felt in a short time in the tunnel itself.

Approach Improvements

A similar situation would apply in New Jersey where exiting traffic from the tunnel combines with local traffic on the helix ramp leading to the opening cut through Bergen Hill. Therefore, to accomplish the desired relief, extensive approach improvements on both sides of the river were necessary.

The new third tube is situated immediately to the south of the existing two tubes, with the Manhattan portal at the northeast corner of 38th Street and Tenth Avenue, adjacent to the portal of the present south tube. To accommodate the increased traffic load, a complex system of entrance and exit ramps separated from city traffic was developed.

At the same time, a new north-south distributor street—designated the Lincoln Tunnel Expressway—was extended to the south from the existing approaches to provide needed connections to additional east-west streets. In addition, portions of city streets in the immediate vicinity of the approaches are being widened.

In Weehawken on the New Jersey end of the tunnel, the third tube portal will share an expanded plaza with the existing two tubes. The present plaza is being widened by five lanes to provide for eighteen lefthand toll booths. These booths, in addition to affording convenience to drivers, enable greater volumes of traffic to be handled. At the same time, the helix ramp forming the main approach to the tunnel has been widened.

Originally three lanes in each direction, this ramp now has four lanes on the ascending grade in the westbound direction between its terminus at the tunnel plaza and the top of the helix. In addition,

New York Approaches to Lincoln Tunnel.

a new underpass for local tunnel-exit traffic toward Hoboken has been provided. The west end of the approach connecting with the New Jersey Turnpike, US Route 1, and New Jersey Route 3 has also been widened by two lanes to provide four lanes in each direction for both tunnel and local non-tunnel traffic.

Traffic Operations

The guiding principle in all functional and operational planning for the expanded Lincoln Tunnel has been flexibility. Approaches on both sides of the river have been developed so that the three tubes can be operated with two tubes, or four lanes, to handle the predominant flow in either direction or to adjust the lane-capacity to carry balanced-flow traffic. This is accomplished by reversing the lanes of the center tube and by using maximum safeguards to prevent accidents.

The existing north tube will continue to carry New Jersey, or westbound, traffic in both lanes. The present south tube will become the center tube and will carry either New York-bound traffic in both lanes, New Jersey-bound traffic in both lanes, or two-way traffic. This was the first tube of the tunnel put in operation in 1937 and was used successfully for two-way traffic until the north tube was opened in 1945. The new third tube to the south will carry only New York-bound traffic.

Under normal operating conditions, use of the center tube's two lanes will depend on the amount of traffic in each direction. At certain times, however, demand may exceed tunnel capacity. Under these conditions, the degree of backup on the approaches must be considered and the center tube will be used to minimize the backup on one of the approaches or equalize the backup in each direction. In the late evening or early morning hours when only two tubes are required, it is possible to close down any one of the tubes. This is especially important from the standpoint of maintenance.

Flexibility of Tunnel Operation

A typical day at the Lincoln Tunnel may follow this sequence of activity: During the night the center tube is closed for cleaning. At

6:30 A.M., New York-bound traffic begins to increase. Accordingly, the center tube is opened to carry New York-bound traffic in both lanes. By 9 A.M., the rush to New York subsides, and congestion is apparent on the New York City approaches because of increasing New Jersey-bound traffic in the westbound (north) tube. One lane of the center tube is therefore reversed to provide three lanes of traffic in each direction.

This operation continues until the start of the evening rush when a major stoppage in the north tube limits the flow of westbound traffic precisely at the time when it is heaviest. The flow through the center tube is therefore immediately changed to provide both lanes for westbound traffic. As soon as the north tube is again operable, the center tube can be returned to two-way operation. After the evening rush subsides and only four lanes or two tubes are required, the center tube is changed to carry two lanes of New York-bound traffic and the south tube is closed for maintenance purposes.

To provide this degree of flexibility in daily operations, a comprehensive traffic sign and signal system readily adaptable to changes in traffic patterns is required. Within the tunnels, signals will be located over each tunnel lane with a separate control for each lane. In the center tube, these signals face both directions and extend out on the New York plaza. These signals give standard green, amber and red indications.

However, because of overhead clearance requirements, the individual faces on signals within the tunnels are only slightly over two inches in diameter. To provide adequate intensity, and furnish added reliability, two signals are provided for each indication—a total of six faces per lane. On the approaches, twelve-inch diameter signals and remotely controlled signs with changing text to conform to changes in the traffic flow will be provided to control the traffic movement. The signs also extend onto the New York City streets.

On Ninth and Tenth Avenues in Manhattan, remotely controlled signs will route traffic to either or both the north and center tubes by means of selectively illuminated arrows. Central control of the signals and remotely changeable signs will be from panels located on the New Jersey side. Additional local control is provided in nearly all cases.

The principal changeable signs consist of triple-faced drums that rotate on the relay-controlled action of small motors built into the sign structure. Each drum has only one line of text. For example, one sign on the New York approach will advise motorists of these operations: With the north tube closed and the center tube carrying westbound traffic, the sign will read, "Keep in Lane." With the north tube carrying westbound traffic and the center tube closed, it will read, "Do Not Enter." Finally, with the center tube carrying both eastbound and westbound traffic, the sign will read, "Two-Way Traffic—Keep Right." These signs can be activated either locally or remotely and conform automatically with the tunnel signal system.

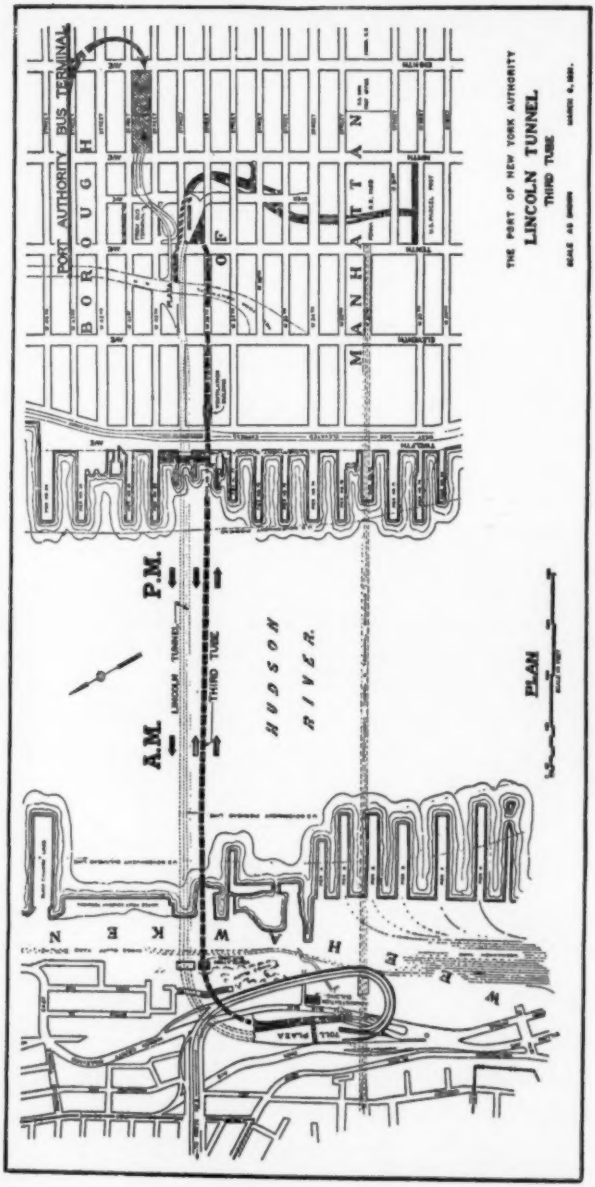
Traffic Officers Control Directional Changes

One traffic officer, normally a lieutenant, will have charge of the traffic flow at the facility at all times. He will be responsible for opening or closing a tube, rerouting traffic approaching the tunnel and changing the direction of traffic flow in the center tube. A typical procedure for changing the direction of traffic flow in the center tube would be as follows:

The officer in charge, after checking the forecast of traffic demand and determining the current situation in traffic flow, will by telautograph, telephone and other means of communication order all personnel involved to prepare to effect the changeover. When the necessary preparations have been made—all men and equipment ready to make the change, the roadways operating normally, and all communications established—the traffic officer in charge orders the first phase of the change.

In this phase all roadways in which traffic is to be reversed are cleared. The sign and signal system necessary to control the changing traffic flow is set into operation. Upon seeing the new directions displayed by the signs and signals, the police officers throughout the facility take their posts to direct the changing traffic. Toll lanes are reversed as necessary for the new operating condition. When the officer in charge is advised that all is ready for traffic to start flowing in the new direction, the second phase of the changeover starts.

In the second phase, the officer in charge checks the signal and



Lincoln Tunnel Three-Tube Traffic Operation.

sign controls to insure that conditions are normal for that stage of the changeover, then orders the traffic to be started in the new direction. Traffic starts through the cleared roadways, in some cases preceded by Port Authority emergency equipment as an extra precautionary measure, and the new traffic flow pattern is established. Personnel involved in making the change then report to the officer in charge that traffic is flowing properly in the new direction, and he checks his sign and signal panel to confirm that correct controls are in effect.

While the time in this total process may take up to twenty minutes, the traffic capacity of the facility will be maintained except for about five minutes while the roadways are cleared in the original direction and traffic starts to flow in the new direction. This is the critical part of the operation. The comprehensive network of communications, the extensive use of remote control traffic devices, and the careful programming of responsibilities and sequence for each of the steps involved in a changeover will all pay dividends in permitting flexible operation of the three tubes with minimum capacity loss on changeovers and with maximum safety.

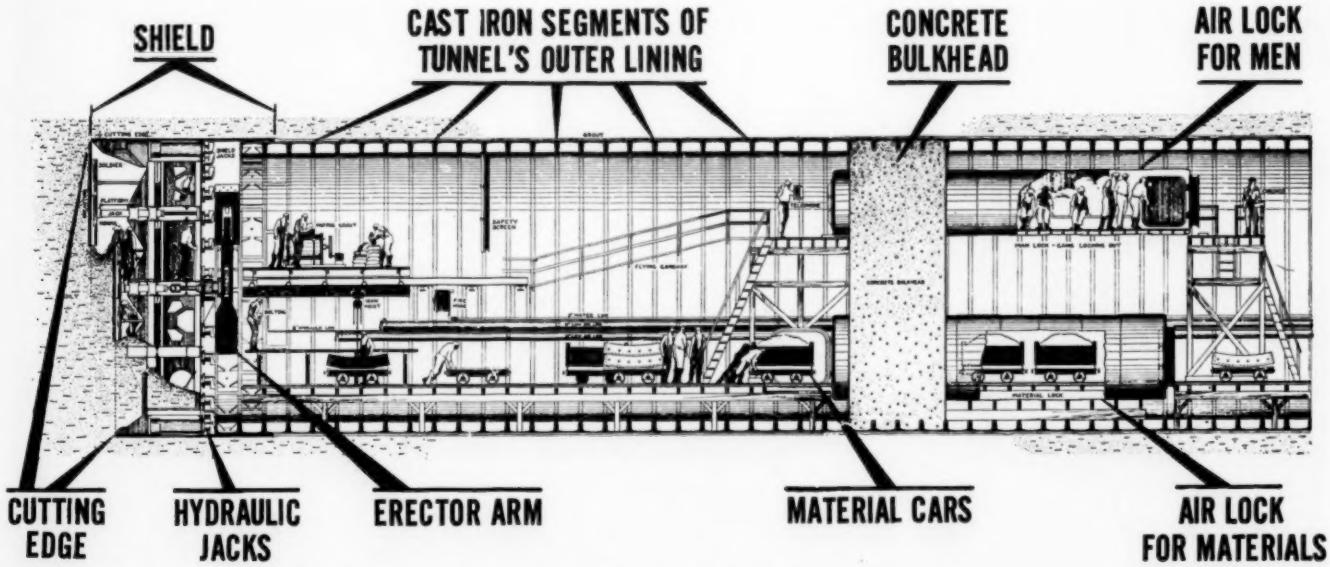
Major emphasis in developing operating procedures and traffic control systems has been placed on the ability to change quickly and safely traffic flow patterns to conform with an unexpected change in traffic demand or a sudden change in available capacity due to vehicular breakdowns in the tunnel. The handling of breakdowns has also been extensively studied to insure the minimum of delay to the tunnel user.

Tunnel Construction

The $100,000,000 third tube of the Lincoln Tunnel was constructed by the shield method. This method has been used almost exclusively for the numerous vehicular, subway and railroad tunnels in New York Harbor.

Construction of the two-lane third tube was begun on September 25, 1952. Most of the footage of the 8,013-foot-tunnel (portal to portal length) was cut through the silt beneath the Hudson River. However, at each end of the tunnel and also under the Palisades a considerable amount of solid rock was encountered.

Aerial View of New Jersey approaches to Lincoln Tunnel as Third-Tube Project Nears Completion.



Artist's Conception of a Longitudinal Section of Lincoln Tunnel During Construction.

In constructing the tunnel under the river, a giant prefabricated steel shield was erected at the bottom of a fifty-five-foot-deep shaft excavated in the solid rock near the shore in Weehawken, New Jersey. The shield, resembling a glass tumbler laid on its side, weighed 240 tons, was eighteen feet, four inches long and thirty-one feet, eight inches in diameter. Briefly described, this cylindrical steel shield consisted of three parts:

The front portion or cutting edge; the center part designed to give stability to the shell; and the rear section designed to form an envelope around the completed forward end of the circular tunnel. The internal diameter of the shield rear section is thirty-one feet, two inches, giving a two-inch differential between the tunnel and the shield.

Based on previous experience, this differential was considered sufficient to permit steering of the shield without binding. The shield, costing a quarter of a million dollars, was designed by the Engineering Department of The Port of New York Authority. Although the functional aspects of the shield did not differ fundamentally from those previously constructed for Hudson River tunnels, structurally great changes over previous shields were made. This was the first time an all-welded shield design was employed.

After the shield was erected in the New Jersey shaft, twenty-eight hydraulic jacks known as "shoving" jacks with a thrust of 200 tons each were installed inside and to the rear of the shield. As the shield moved forward, rock blasted loose ahead of it was admitted through bulkhead trap doors. After passing through the rock the shield encountered river muck. The shield "cooky-cut" 5,486 feet under the Hudson River through this muck. As the sharp cutting edge of the shield moved forward, about 80 percent of the muck was pushed aside and 20 percent was allowed to ooze into the tunnel through the traps. This muck acted as ballast and was later removed.

About 200 sandhogs working around-the-clock six days a week were employed in the tunneling operation. They worked in "free air" (under normal pressure) as the shield moved through the rock. Once under the river, where the muck in a semi-fluid state creates an external pressure on the shield, up to thirty pounds of compressed air per square inch above the normal fifteen pounds were pumped into the tube.

Some of the sandhogs worked in the front end of the shield, excavating material; others worked in the rear, assembling the cast-iron ring sections which form the permanent outer sheathing of the tunnel. Fifteen sections were used to form a complete ring thirty-one feet in external diameter and thirty-two inches long. As each ring section was bolted in place, the hydraulic jacks were braced against the completed ring. The jacks there pushed the shield forward in thirty-two-inch shoves thus making ready for the next ring section to be installed. More than 2,000 rings were required for the entire tunnel.

The tunneling of the under-river section, which began in the Weehawken ventilation shaft in November, 1954, "holed through" in June, 1956. Removal of the ballast muck followed. Simultaneously with the under-river work, the New Jersey extension to the under-river section was bored about 830 feet through the Palisades rock formation from the ventilation shaft to the new portal, and work went forward on the section between the New York ventilation shaft and the New York portal. This was an open-cut operation in which more than 60,000 cubic yards of dirt and rock were removed.

The finishing work on the third tube is now in progress. It is estimated that by June, 1957 the third tube will be available for operation.

Because of the continual emphasis upon safety by the Port Authority and its contractors on the under-river tunneling, a record that promises to be unique for a job of this nature, is being established. It no doubt results largely from the carefully planned safety program that has gained the respect and co-operation of all concerned.

Additional Facilities

The Lincoln Tunnel third tube was conceived as one phase of an overall program for relief of trans-Hudson traffic. It is significant that the proportion of total trans-Hudson traffic having origin or destination in areas other than Manhattan has been growing steadily. Traffic generated in these areas was 48 percent of trans-Hudson traffic in 1949; by 1953 it had increased to 56 percent on weekdays and 70 percent on Sundays. At the same time, estimates indicate that total trans-Hudson demand by 1960 would amount to 105,000,000

vehicle crossings, equal to the capacity of the George Washington Bridge, Holland Tunnel and expanded Lincoln Tunnel.

Consequently, in 1954 the Port Authority joined with the Triborough Bridge and Tunnel Authority in the most comprehensive study of arterial highway needs ever undertaken in the New York metropolitan area. This study was released early in 1955 and recommended that a second deck be added to the George Washington Bridge together with extensive arterial connections on both sides of the river to provide needed capacity on the northern end of Manhattan. In addition, a new bridge across the Narrows linking Staten Island and Brooklyn was recommended. This bridge, combined with new arterial highways across Staten Island and through Brooklyn, would provide the essential southern bypass of Manhattan.

The necessary legislation from the states of New York and New Jersey has now been obtained in connection with the construction of these facilities.

Estimates indicated that between seven and eight million vehicles now using the Lincoln and Holland tunnels will use the Narrows Bridge. The addition of a second deck on the George Washington Bridge will not only relieve that facility of its increasing traffic burden but will further contribute to the relief of the Lincoln Tunnel by accommodating diversions from that facility.

The Analysis of Work-Trip Data: Relationships and Variances

HOWARD S. LAPIN

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ANALYSIS of automobile traffic data for Philadelphia suggests a means toward greater understanding and predictability of work-trip generation between areas of residence and areas of heavy employment density. The method of study includes establishing a mathematical equation that describes an inverse relationship between interzonal trip volumes and the respective time-distances for peak-period travel between them.

While the correlation of the two measures for auto-driver trips was found to be high enough (r-0.92) to warrant some predictions from the curve established, it should be noted that not all points could be plotted close to (that is, within one or even two standard errors of) the curve.[1] Rather than providing disadvantages, these divergent points as a rule show important aspects in the relationships between the residence and workplace zones. Thus, the study gives as much attention to observed deviations as to the data that lie closer to the fitted curve.

[1] For purposes of prediction of trip volumes between any two zones, this paper emphasizes the need to study characteristics of the origin and destination zones and the quality of transportation service between them. The high correlation factor for all the plotted points does not eliminate the possibility of a wide deviation from the "fitted" curve by a particular interzonal trip volume.

Once the curve of relationship between the two variables has been established, trip volumes for a particular interzonal combination can be recalculated from the new data. In the matrixes showing the actual trip volumes (Tables 1 and 2) it should be noted that

Table 1

AUTO-DRIVER WORK TRIPS, RESIDENCES TO WORKPLACES
PHILADELPHIA, 1947

From Residence Origin		*To Section of Workplace Destination*				
Section	*Total Trips*	*A*	*B*	*C*	*D*	*E*
A	687	431	21		89	
B	8,224	1,708	3,523	150	865	1,173
C	9,038	1,659	1,495	1,563	2,439	1,060
D	30,920	7,191	3,499	1,882	10,914	3,238
E	15,395	2,329	1,292	285	1,271	4,703
F	14,737	1,701	1,195	340	564	2,081
G	11,502	1,153	1,124	121	159	1,581
H	4,952	549	122	21	264	384
I	21,951	3,064	1,107	303	1,801	2,407
J	47,213	5,777	2,528	646	2,963	9,151
K	35,460	3,307	1,529	369	1,194	5,160
L	2,725	191	20		60	219
Total	202,804	29,060	17,455	5,680	22,583	31,157

From Residence Origin		*To Section of Workplace Destination*						
Section	*Total Trips*	*F*	*G*	*H*	*I*	*J*	*K*	*L*
A	687	94			26		26	
B	8,224	196	190		129	111	216	23
C	9,038	345	44	42	85	156	150	
D	30,920	1,240	552	156	612	878	617	141
E	15,395	1,680	1,604	166	575	645	700	145
F	14,737	4,817	1,010	382	586	890	989	182
G	11,502	1,954	2,995	44	101	260	1,872	138
H	4,952	810	349	1,681	431	140	181	20
I	21,951	3,924	958	103	5,236	1,972	935	141
J	47,213	7,527	3,239	667	2,907	8,665	2,820	323
K	35,460	4,263	5,493	40	1,254	1,646	10,073	1,132
L	2,725	220	289		41	133	777	775
Total	202,804	27,070	16,723	3,281	11,983	15,496	19,356	3,020

total trip origins for a particular zone are listed in the vertical column to the left of the table, and total destinations at workplaces are shown for each zone at the foot of the table.

It is clear that these two measures relate directly to numbers of

Table 2

INTERZONAL AUTO-DRIVER WORK TRIPS
PHILADELPHIA, 1947

From Residence Origin		*To Section of Workplace Destination*				
Section	*Total Trips*	*A*	*B*	*C*	*D*	*E*
B	4,738	1,708		150	865	1,173
C	7,475	1,659	1,495		2,430	1,060
D	19,865	7,191	3,499	1,882		3,238
E	10,547	2,329	1,292	285	1,271	
F	9,738	1,701	1,195	340	564	2,081
G	8,369	1,153	1,124	121	159	1,581
H	3,251	549	122	21	264	384
I	16,574	3,064	1,107	303	1,801	2,407
J	38,225	5,777	2,528	646	2,963	9,151
K	24,255	3,307	1,529	369	1,194	5,160
Total	143,037	28,438	13,891	4,117	11,511	26,235
Percent	100.00	19.88	9.71	2.88	8.05	18.34

From Residence Origin		*To Section of Workplace Destination*					
Section	*Total Trips*	*F*	*G*	*H*	*I*	*J*	*K*
B	4,738	196	190		129	111	216
C	7,475	345	44	42	85	156	150
D	19,865	1,240	552	156	612	878	617
E	10,547	1,680	1,604	166	575	645	700
F	9,738		1,010	382	586	890	989
G	8,369	1,954		44	101	260	1,872
H	3,251	810	349		431	140	181
I	16,574	3,924	958	103		1,972	935
J	38,225	7,527	3,239	667	2,907		2,820
K	24,255	4,263	5,493	40	1,254	1,646	
Total	143,037	21,939	13,439	1,600	6,680	6,698	8,480
Percent	100.00	15.34	9.40	1.12	4.67	4.68	5.93

resident workers and numbers of jobs, respectively. Thus, as revised current information becomes available from census, employment sources or other sources, it should be possible to modify the existing data on work-trip volumes. Or on the other hand, population and employment forecasts considered in terms of area distributions should be subject to analysis for their effects on current work-trip patterns.

Careful consideration should be given to those origin-destination zone combinations for which the points plot at a distance from the fitted curve. At least two types of study should be given these points of notable deviation:

1. Compare the nature of the resident labor force with the nature of jobs in the destination zone.
2. Notice quality of routes and service between the zones.

Points located above the curve appear to correspond with a close matching of the resident workers with the employment in the destination zone, and a situation where transportation service is at least adequate. Points located below the curve may be the result of poor matching of the resident and workplace industrial characteristics or poor transportation service, or both conditions.

Another point, of course, is that jobs in a particular destination zone on the periphery of the city may largely be filled by residents outside the study area. As in the Roxborough section of Philadelphia (Figure 1, section H), this could well be the result of limited or difficult access from other areas within the city.

To substantiate fully an inference of this nature, data for trips originating outside the city limits are required. Analysis of trips of origins external to the city, and of those external to the metropolitan survey area are supplementary to the study of area relationships and traffic service within the city.

Philadelphia Employment Characteristics

To aid the analysis of trip volumes and their adherence to or deviation from the mathematically fitted curve, it is desirable, where possible, to analyze the constituency of residential areas for industry or occupation of the residents—and similarly to examine the industrial nature of the particular employment zones.

Toward this end, data were prepared for Philadelphia; however, they are not considered sufficiently precise other than in comparing proportions, since the boundaries of the grouped area-units used did not coincide exactly with the areas delineated as sections A through L, Figure 1. Place of residence of workers in the following categories was summarized: industrial, trade and finance, profes-

FIGURE 1. Philadelphia Planning Analysis Sections.

sional and related services, government, and domestic and other services.

By far the largest category numerically, was that labeled industrial. This includes all manufacturing and employment in railroads, public utilities, business and repair services, and construction. Table 3 shows a location comparison, by planning analysis sections, of resident workers and the jobs which fall in this category.

In general, this particular comparison indicates the sections which bear close relationship in their daytime and nighttime populations, in terms of about one-half of the city's resident labor force and jobs. Another advantage, for the present study, of the comparison shown is that relatively high proportions of workers in the industrial category drive automobiles to work; hence it is to be

Table 3

PARTIAL COMPARISON OF RESIDENT WORK FORCE AND NATURE OF EMPLOYMENT BY PLANNING ANALYSIS SECTION, PHILADELPHIA

Planning Analysis Section	*Percent of residents employed in industrial jobs, 1940*	*Industrial jobs in section as percent of total jobs, 1946*
A. Central	32	37
B. South	59	60
C. Southwest	46	80
D. West	36	22
E. Lower North	49	43
F. Upper North	56	71
G. Kensington	67	83
H. Roxborough	58	58
I. Germantown	38	25
J. Olney-West Oak Lane	48	24
K. Near Northeast	60	33
L. Far Northeast	43	—
Philadelphia City	50	45

SOURCE: U. S. Employment Service, *Analysis of Employment by Place of Work and Place of Residence, Philadelphia County, 1946.*

NOTE: 1940 data are based on the U. S. census, and 1946 data are estimated by the U. S. Employment Service on the basis of Chamber of Commerce information on manufacturing employment, and for non-manufacturing, on a U.S.E.S. study of establishments employing 50 or more workers.

Industrial employment includes manufacturing, employment in the railroads, public utilities, business and repair services, and construction.

expected that the location distributions of Table 4 will help to explain the interzonal patterns of auto-driver work trips.

Interpretation of the Philadelphia Data

The locations of points plotted for particular interzonal trip volumes were studies in reference to the fitted curve. For example, for

Table 4

PROBABILITY INTERCHANGE: INTERZONAL AUTO-DRIVER WORK TRIPS
PHILADELPHIA, 1947

From Residence Origin		*To Section of Workplace Destination*				
Section	*Total Trips*	*A*	*B*	*C*	*D*	*E*
B	4,738	942		136	381	869
C	7,475	1,486	726		602	1,371
D	19,865	3,949	1,929	572		3,643
E	10,547	2,097	1,024	304	849	
F	9,738	1,936	946	280	784	1,786
G	8,369	1,664	813	241	674	1,535
H	3,251	646	316	94	262	596
I	16,574	3,295	1,609	477	1,334	3,040
J	38,225	7,599	3,712	1,101	3,077	7,010
K	24,255	4,822	2,355	699	1,953	4,448
Percent	100.00	19.88	9.71	2.88	8.05	18.34

From Residence Origin		*To Section of Workplace Destination*					
Section	*Total Trips*	*F*	*G*	*H*	*I*	*J*	*K*
B	4,738	727	445	53	221	222	281
C	7,475	1,147	702	84	349	350	443
D	19,865	3,047	1,866	222	928	930	1,178
E	10,547	1,618	991	118	493	494	625
F	9,738		915	109	455	456	577
G	8,369	1,284		94	391	392	496
H	3,251	499	305		152	152	193
I	16,574	2,542	1,557	185		776	983
J	38,225	5,864	3,591	428	1,785		2,266
K	24,255	3,721	2,279	271	1,133	1,136	
Percent	100.00	15.34	9.40	1.12	4.67	4.68	5.93

the trip-interchanges from origins in sections E, F, J and K to the central business district A, the four points were found to plot below the curve. Destination A is relatively low in industrial employment as Table 1 shows, but the four residence sections each have half or more of their resident wage-earners in this type of employment. So the employment data explain these deviations from the curve and their negative sign.

On the other hand, relatively low proportions of the residents in sections D and I are engaged in industrial employment. Hence we might expect trips from D to the central business district and from I to A to be equal to or greater than the curve value. The value for D–A is indeed above the curve. But I–A just about equals the curve value. In this case, the failure of the I–A point to reach the expected value leads us to investigate the quality of the transportation service or other frictional factors between the two sections.[2]

To evaluate quality of transportation service on this basis, let us take a more controlled situation—one where two residence zones are about equidistant from an employment zone, and where the relative proportions of the industrial employment are about equal.

For this example, consider E and J as the residence sections and G (Kensington) as the destination. Four-fifths of the jobs in the Kensington section fall into the industrial category, so we should reasonably expect that points E–G and J–G would both exceed the predicted curve value. Point E–G does exceed the curve value as expected, but J–G falls below.

The most probable explanation of the latter deviation appears to lie in the quality of vehicular routes available. For peak-hour travel a number of arterial routes can be followed from section E northeast to the employment area of Kensington. But there is a dearth of arterial routes southeast from J to Kensington.

Thus the *a priori* inspection of the curve leads to an important finding relative to the circulation system—not only that a dearth of routes exists, but that an unexpressed demand for these routes, from J to G, may be assumed to exist. (As a matter of fact, the proposed Tacony Creek Parkway will fill part of this need, but it may also be predicted that the generated traffic will considerably exceed that

[2] Or the cause might be another and closer center of non-industrial employment. The fact appears to be that direct vehicular routes from I to A are quite poor in traffic service.

normally calculated from assignments of origin-destination traffic survey data.)

This aspect of unexpressed travel demand is important. It indicates one means by which implicit and unreported traffic needs might be sought out and evaluated. Further, it indicates one of the ways by which traffic volumes *induced* and *generated*[3] by new facilities might be estimated in advance. It is clear that none of the urban traffic survey methods now in use would turn up the potential need that appears to exist for improved vehicular transportation facilities between Sections J and G.

Another use of the curve might also include *diverted* as well as the other two types of traffic on new routes. As time-distance decreases, a quantitative measure of the traffic interchange between any two zones is given by the curve. Thus as time-distance between two zones is decreased, an estimate might be made of the increased volume of traffic which may be expected.

Another point in interpreting the curve: as the average speed of traffic movement throughout the city increases, the entire curve is shifted horizontally to the left. On this basis, a family of prediction curves might be drawn to represent a consecutive series of average speeds, and the interzonal relationships as transportation facilities are improved generally.

The concept of a family of prediction curves brings in the question of comparability of similar curves, from city to city. On a similar basis, the curve described by all vehicular trips in Detroit plots along a hyperbolic curve quite close to the Philadelphia auto work-trip points (an assumption of 12 mph was made for average speed to convert the Detroit mile-distance points to time-distance—Philadelphia's average speed was 11.5 mph). See Figure 2.

Assembly of the Data

The method of assembling data consists in comparing actual numbers of trips from homes to work with the probable numbers which

[3] Generated traffic is that which is made up of entirely new trips (new residents, new jobs, etc.). Induced traffic is made up of travelers who have changed their destinations because of the improved facilities. Diverted traffic is made up of travelers whose trip origin and destinations remain the same, but change their route to effect a saving in time and effort.

might be expected if physical distance between origins and destinations had no effect. Probable volumes of trips made between any two zones thus are calculated to depend solely upon numbers of

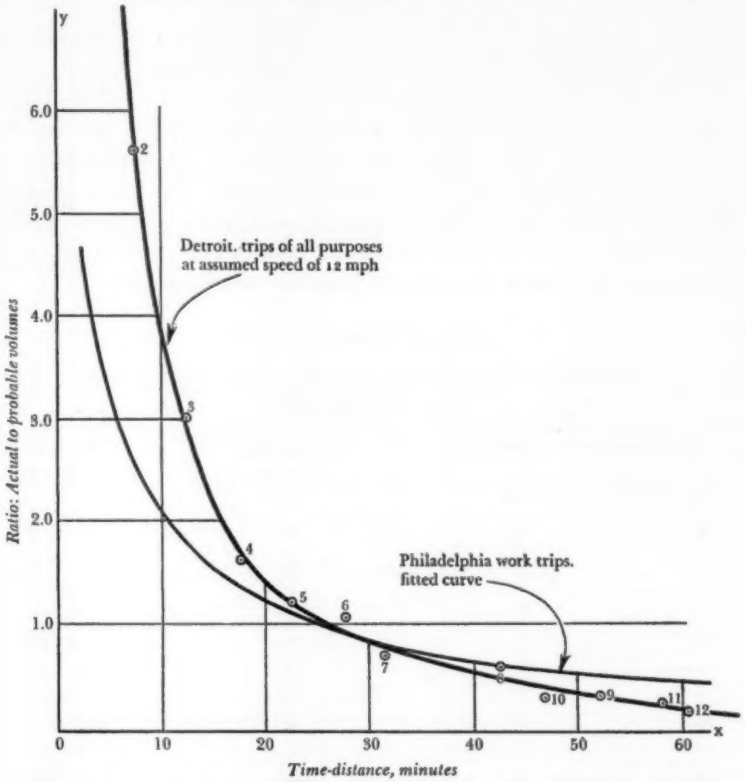

FIGURE 2. Curve for Interzonal Trips in Detroit: 1953, Comparison with Philadelphia curve.

resident workers and numbers of jobs, and not upon the relative ease or difficulty of moving between homes and workplaces. Ratios are then calculated between the actual and probable interchange volumes (as in Table 4).[4]

By the method of least squares, a mathematical relationship is derived to explain changes in the ratios in terms of the peak-hour

[4] See: *Detroit Metropolitan Area Traffic Study, 1955*, page 92.

time-distance of the trips between residence origin and work-place destination. (Data used in plotting the curves are shown in Tables 5 and 6.)

In the 1947 example of Philadelphia auto-driver trips from home to work, 84 percent of the variations in the actual-trip–probable-trip ratios were explainable in terms of the time-distance factor.

The first step in measuring distances was to plot the location of centroids of population and of located employment within the various analysis-areas. This was accomplished with dot-maps of population residence and employment location. The time-distances were taken from peak-hour driving times. Twenty interzonal traffic interchanges, most of which exceeded volumes of 1,000 trips, were selected to represent the various possible combinations.

Table 5

PROBABILITY RATIOS FOR INTERZONAL AUTO-DRIVER TRIPS*
PHILADELPHIA, 1947

Interzonal Combination		*Time-Distance, Minutes*	*Ratio, Actual to Probable*
From	*To*	x	y
B	A	15	1.813
I	A	27	0.930
C	B	18	2.059
I	B	43	0.688
O	C	11	3.290
J	C	42	0.587
J	D	33	0.963
K	D	44	0.611
D	E	31	0.889
B	E	26	1.350
G	F	15	1.522
J	F	10	1.284
E	G	15	1.619
J	G	19	0.902
D	I	24	0.660
K	I	20	1.107
I	J	11	2.541
D	J	34	0.944
G	K	9	3.774
J	K	17	1.244

* Work trips only. See Figures 2 and 3.

A correlation study of the two variables was made and a curve was fitted (Figure 3). The hyperbolic curve $\frac{1}{y} = 0.151 + 0.0327x$ was fitted by the method of least squares. The coefficient of correlation between the two sets of data was calculated as 0.92 and the standard error of estimate as 0.157 (in terms of terms of y values). Once the correlation is established, the analysis of deviations and inference of quality of transportation service can be undertaken.

An indicated next step would be to attempt to systematize the matching of labor-force characteristics of the origin and destination areas in terms of index numbers. These data might then be used in deriving the curve of interzonal work-trip exchanges, by multiple correlation techniques.

Further Use of the Data

The work-trip data are adaptable to current revisions and to the forecasting of future travel volumes. As it becomes available, new information on population or on the volume of employment can be used to adjust the proportional distribution of work trips.

Table 6

PROBABILITY RATIOS FOR INTERZONAL VEHICLE TRIPS
DETROIT, 1953

Zonal Interchange Number	*Interchange-Distance, Miles* x	*Ratio, Actual to Probable* y
1	1.03	9.46
2	1.48	5.62
3	2.51	3.06
4	3.48	1.67
5	4.48	1.27
6	5.50	1.15
7	6.32	0.72
8	8.51	0.61
9	10.42	0.33
10	9.38	0.31
11	11.61	0.25
12	12.13	0.19

See Figure 2.

Outlines for such use of this method of trip tabulation and analysis are now in preparation. Trips segregated by purpose of work from area of origin to area of destination, and classified by

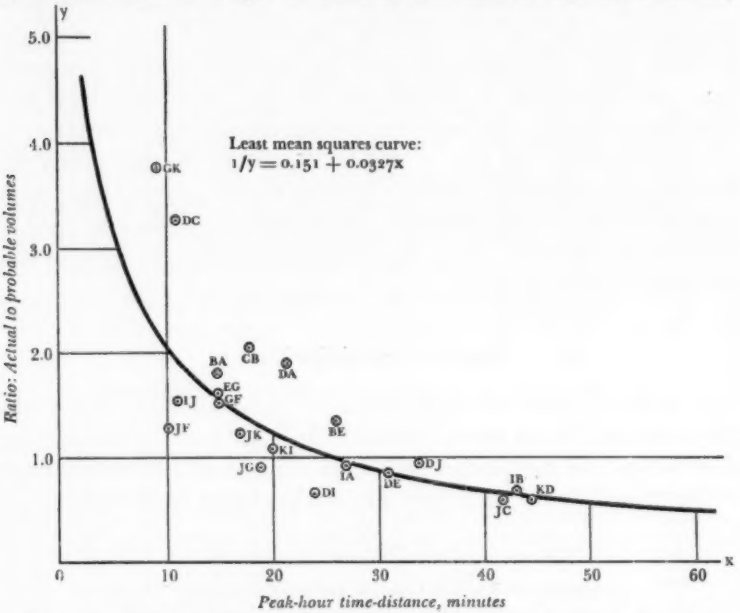

FIGURE 3. Prediction Curve of Interzonal Work Trips (Auto Drivers Only). Data for Philadelphia: 1947.

mode and by worker's industry or occupation are being tabulated in current studies for San Diego and for Washington, D.C.

In the San Diego study, future peak-hour travel volumes are to be estimated on the bases of anticipated ratios of change in population and employment. In the Washington analysis, future traffic volumes are to be studied on the basis of unit trips generated: that is, the trips from bases of origin are to be segregated by purpose (work and others) and the generation factors are to be correlated with various economic and geographic indexes.

Limitations of the Study

Several broad categories of work trips have been excluded from the present analysis. These include trips originating within the

city and destined beyond the city line; work trips originating beyond the city line and terminating within the city, and work trips which begin and end within a particular zone. For these latter groups, at any rate, it may be assumed that major facilities would not be required because of the short lengths of the trips. The external origin or destination work trips compose relatively small proportions of the total travel. They are omitted for simplification of the present analysis, but should be included in a more comprehensive study.

Omissions of intrazonal trips can of course be diminished by reducing the size of zones considered and thereby increasing the number of zones and the complexity of the interchange matrix. For other reasons also, such as increasing accuracy by reducing error of locating the zone centroids, it would be desirable to employ smaller zones in the analysis. As zone interchanges increase in number, however, the problem of analysis would soon reach proportions solvable only by complex machine procedures. This is the direction to be taken.

A mathematical limitation: the present study is based on minimum interzonal trip volumes of about 1,000 (representing not less than forty-five interviews per point). While it would be advantageous to conduct the present study with much smaller area-units, it is believed that reliability limits the minimum areas of the zones to those in which this minimum level is retained. This introduces the possibility of more intensive interviewing in selected areas on a regular and continuing basis, to increase the scope and intensity of the city-wide traffic survey.

Another limitation is in the mechanics of the origin-destination interview survey which furnished the data for the present study. Data gathered at the work-place, rather than in homes, might prove more reliable for detailed area-analysis of work trips, particularly in terms of industrial groupings.

Acknowledgments

The writer acknowledges his indebtedness to those persons who have previously studied measures of interactance among a number of base and destination zones in cities. He is most indebted to Pro-

fessors Mitchell and Rapkin for their suggestions for research on specific systems of traffic in the book, *Urban Traffic,* published in 1954. Work on zonal interactance in Detroit and Toronto metropolitan area publications has also been studied.

Other invaluable aids include: Dr. Ernest Jurkat of Marketers Research Service for his structuring of metropolitan areas in terms of population densities and time-distances; the Philadelphia City Planning Commission publication, *Person-trips to the Central City* (1954) prepared by Fred Sass, for valuable reference; and in criticizing and furnishing ideas, John Rannells and Dr. William Wheaton of Philadelphia, and Gordon Sharpe of the Bureau of Public Roads.

This analysis is based on specially prepared runs of O-D work-trip cards completed in June, 1955 with financial aid from the Philadelphia City Planning Commission. This support made possible the current effort.

Traffic Estimation

A REVIEW

Highway Traffic Estimation. By Robert E. Schmidt and M. Earl Campbell. Saugatuck, Conn.: The Eno Foundation for Highway Traffic Control. 247 pp.

SCIENTIFIC prediction — a data-controlled imagination — emerges from industrial history as a major factor in success. The man who can foresee what type of motor vehicle or transportation facility enough people will prefer . . . and how long that preference, with practicable modifications, will last . . . is likely to go down in the history of business as a captain of industry or a distinguished engineer.

Had planners of early Boston, its streets originating in cowpaths, been able to predict future traffic requirements, today's congestion would have been largely solved 327 years ago.

Therein lies the frightful interval between the seed and the timber. Progress moves by steps, not by leaps. Today, turning specifically to the field of traffic, research engineers are gradually amassing and interpreting data that go far toward providing what Goethe called "illuminating patterns of experience."

These patterns can serve as a guide for highway planning, for traffic design, and for the engineers who need to compute from projected data the traffic requirements of the present—and to predict the probable effects of change in traffic facilities.

In this Eno Foundation book, "Highway Traffic Estimation," Robert E. Schmidt and M. Earl Campbell deal with scholarly balance and meticulous reasoning in three aspects of traffic estimation:

1. The traffic-generating characteristics of major urban land areas.
2. The relative attraction of different routes that serve traffic between zones of origin and destination.
3. The growth of traffic from increases in population, from the ownership of vehicles, and from increases in the use of vehicles and other factors.

The authors relate their appraisal of specific traffic facilities to their environments in terms of significant economic and sociological data. Their work digests and collates, in a logical and usable organization, essentially all the research to date in this field.

The amount of travel each family engages in varies with the size of that family's income and with its socio-economic level. Figures show that clerical, professional, and government workers travel much more than subsistence farmers; and typical data are presented to document the variations. Eighty percent of all travel is from home to work. Charts and tables show how to compute the trips.

For all of our decentralizing shopping centers and regional branch stores—from increasing motorization—central business districts are not likely to disappear. Their present form, however, may radically change. Growing residential concentrations in suburban areas cause the development of shopping centers. They support other commercial, industrial, and professional activities in the suburbs. A city of 25,000, let us say, has specialized services that operate from a central location. It needs but a minimum of outlying grocery stores, drug stores, and other types of neighborhood establishments.

In larger cities, a greater assortment of furniture, clothing, banking, automotive, and entertainment services can be found in each large concentration of population *outside* the CBD. Still, within the central district remain the largest department stores, specialty shops, and main business offices. These patterns of urban development, Mr. Schmidt and Mr. Campbell set forth in terms of the vehicular generation.

This book presents ninety-three tables and charts, and two copious appendices. The work deals in usable ways with land-use and terminal generation, the distribution of traffic, and traffic growth. It deals also with "the critical hour," and lists many supplemental references.

"Highway Traffic Estimation," in the opinion of this reviewer, who as a journalist has been dealing with traffic problems for more than a quarter of a century, constitutes a highly significant contribution—specifically applicable as a sort of estimation slide-rule—in the field of scientific traffic prediction.

R.E.